AN ECOLOGICAL STUDY OF

Anogeissus pendula EDGEW

WITH SPECIAL REFERENCE TO SEED GERMINATION AND SILVICULTURAL TREATMENTS

THE THESIS

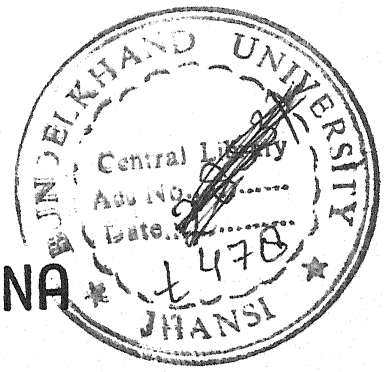
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IN BOTANY



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This is to certify that this thesis is the original piece of research work of Mr. Suneel Kumar Saxena, Department of Botany, Bipin Bihari Mahavidyalaya, Jhansi. He has worked under my guidance and supervision.

It is further certified that :

* The thesis has been duly completed.
* The candidate has worked for more than the requisite minimum period required under the Ph.D. Ordinance of the University.
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D E C L A R A T I O N

I hereby depone that with the exception of the guidance and suggestions received from my Supervisor Dr. J. P. TRIPATHI, M.Sc., Ph.D., F.A.P.S., Department of Botany, Bipin Bihari Mahavidyalaya, Jhansi (U.P.), this is my original piece of research work carried out in the Ecological Research Laboratory, Deptt. of Botany, Bipin Bihari Mahavidyalaya, Jhansi, for the Degree of Doctor of Philosophy in Botany.

I further declare that the data presented here-in have not been submitted anywhere else for this or for any other award.

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A C K N O W L E D G E M E N T S

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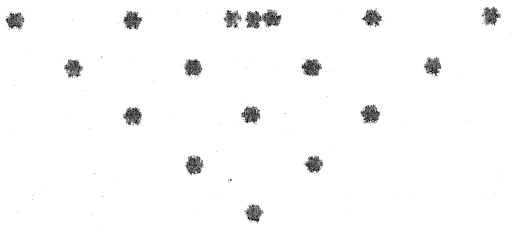
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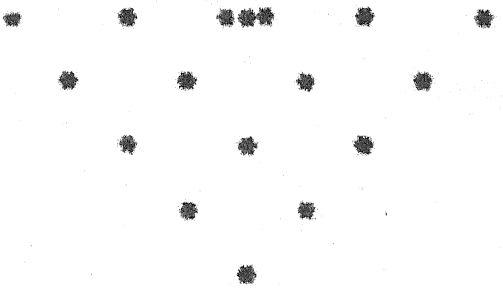
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C H A P T E R - I

G E N E R A L I N T R O D U C T I O N

C H A P T E R - I

G E N E R A L I N T R O D U C T I O N

1.1 P R E L U D E

THE principal forms of vegetation - trees, shrubs and herbs are the alpha and omega of our environment. Broadly, vegetation, soil, air, water, micro and macro fauna form our environment; but of all these components, the vegetation plays a major role in stabilising the structural configuration of Nature. Trees, shrubs and herbs can rightly be called the trinity of our environment as they collectively affect in modulating the structure[362].

Trees, shrubs and herbs form a part of the forest community. Each of these Life-forms individually influence the Nature but cumulatively as forests they play a unique conservation role in fighting various evil forces of Nature.

When trees grow assembling in a community, a FOREST is born, an ENVIRONMENT is created and the process of plant and animal SUCCESSION follows.

Forests are essential for human survival and impose vital impact on climate, soil erosion and floods. Forests have

contributed to the prosperity of our NATION as a whole and they are the source of human history, Godly gifts and are faithful friends of mankind.

"Forest is a peculiar organism of unlimited kindness and benevolence that makes no demand for its sustenance and extends protection to all beings, offering shade even to the axe-man who destroy it." said Bhagwan Gautam Buddha.

Trees are vitally and intriguingly connected with the life of mankind. The poet and the musician, artist and the writer, primitive people and the civilised societies, all have come under their spell. The words in a poem "TREES" which read ut infra :

"I THINK THAT I SHALL NEVER SEE
A POEM LOVELY AS A TREE"

convey latently a number of unsaid things the beauty they spread in the world; the change in their colour to suit the season; the cooling shade of their leafy arms, and the fruits and flowers they bear for our joy.

1.2 T H E T R E E C U L T

THE TREE is envisaged as a perfect creation of Nature. Its pleasant sight gives strength, its colour and form inspires the beauty, and its regal presence permeates the

PLATE - 1. THE STURDY SON OF THE SOIL : ANGIOPTERIS EVECTA HOOK. - TAKE A STRONG WILL TO LIVE.

atmosphere of great solace. (Plate - 1).

The strange and astounding cult of worshipping trees as deities, dates back to the dawn of time. Indian history and mythology are full of beliefs with regard to trees. The Buddhists had - 'THE TREE OF ENLIGHTENMENT', the Muslims - 'THE TREE OF HOSPITALITY', the Persians - 'THE TREE OF IMMORTALITY', the Jews - 'THE TREE OF TEMPTATION' and THE BIBLE tells of 'THE TREE OF KNOWLEDGE'.

The Indians have been worshipping the trees since the times immemorial for several reasons viz., fulfilment of one's desire, attainment of wisdom, propitiation of evil spirit and cure of disease etc. etc. They are also regarded as the symbol of the unity of life.

Not only did our ancients hold trees in reverence, they also retired to the sanctuary of the forest to spend the evening of their lives in the midst of tranquil Nature, known 'VAN PRASTHA'. The Great Kalidas in his epic had his heroine Shakuntala bidding farewell to all the plants and trees of the Ashram where she was once brought up before leaving for her husband's home.

1.3 MAN VERSUS TREES

INSPITE of such traditions of mutual relationship between man and trees, his attitude towards them has taken a

turn in the reverse direction. The very materialistic approach in resorting to environmental degradation has made the man vainfully MASTER over Nature rather than trying to establish bonds of friendship with it.

Animals and trees are the co-ordinates of Nature but due to unlimited exploitation, the balance of the life of animals and plants has been disturbed greatly. At present there are about a quarter of a million different plant species in the world. If man continues to exploit the natural resources at such a tremendous rate, one sixth of the plant population could be extinct before the year 2050. Many of them would even disappear without being properly identified and without their benefit to the human race[342]. The extinction of plants would act as a slow poisoning to the Nature which in turn would become helpless to save the mankind.

India's once magnificient forests are marching towards the way of tormaney and due to various man-made pressures from all corners the forests are suffocatively under great tension. The Great HIMALAYAS - the pride, not only of India but of the world as well, are becoming denuded to a large extent by human intervention. The Western-ghats, the Nilgiris, the Vindhyas and many such others from Kashmir to Kanyakumari and from East to West throughout, the country is facing more or

less the same plight. The way our forests, that were built up in hundreds and thousands of years are being robbed, plundered and destroyed ruthlessly by man is nothing but a 'NATIONAL SHAME' for all the citizens dwelling in this sub-continent.

A recent study by the United Nation's Commission for Asia and the Pacific, has reported the destruction of tropical forests in South-east Asia and India as,"One of the greatest tragedies of our times." The study further says, "The degradation of forests in Asia is a classic example of third-world problem which they must not ignore."The report also states in terrorem that the disappearance of irreparable forests also means the loss of the earth's 'GREEN LUNGS' with incalculable consequences for the ecological imbalance of our planet[33].

Our poets and sages have been writing and explaining the importance and utility of forests since the dawn of civilisation. They even associated them with religion, yet the man for his pretty profits, has totally ignored and forgotten the forest wealth and is constantly raping the flora.

1.4 C O S T O F D E V E L O P M E N T

THE concept of 'INFRA-STRUCTURE' means roads, railways, electricity, hydel power, mining, industrialisation and urbanisation etc., but unfortunately the very infra-structure of

life - 'THE FOREST' is totally missing in economic policies.

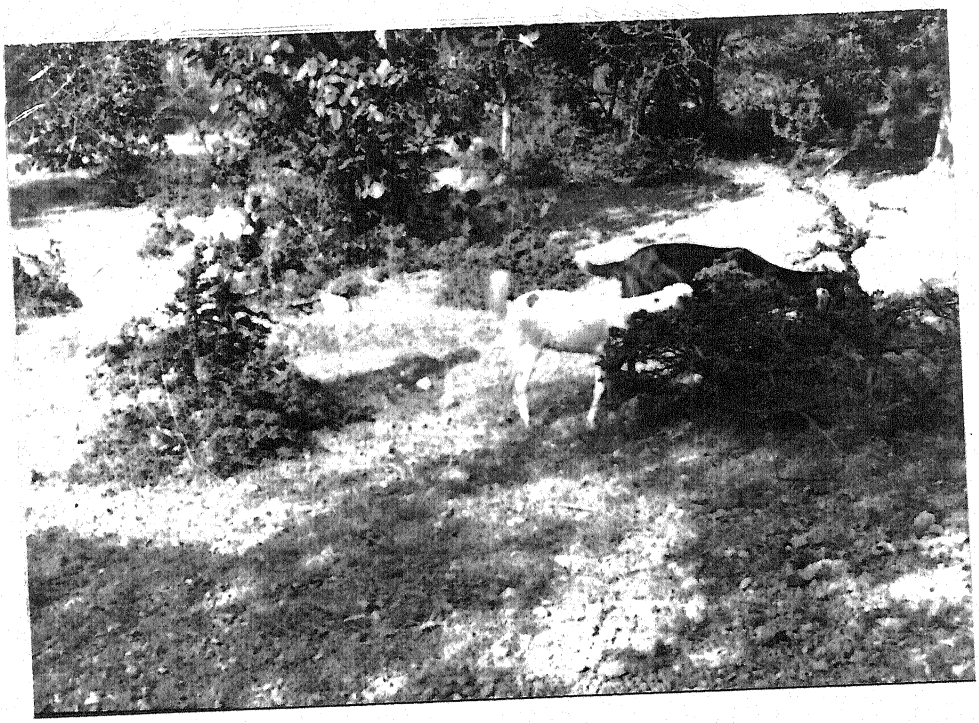
Are not our large industrial project,'The new temples of modern India', mostly built by replacing, 'The more venerable temples namely - THE FORESTS ?' The 'ROLLER OF PROGRESS' is paving the way for projects after projects by razing much of the evergreen forests. Hence, the day is not far when lush greenry would be a glory of the past and the rivers would present a brazen look.

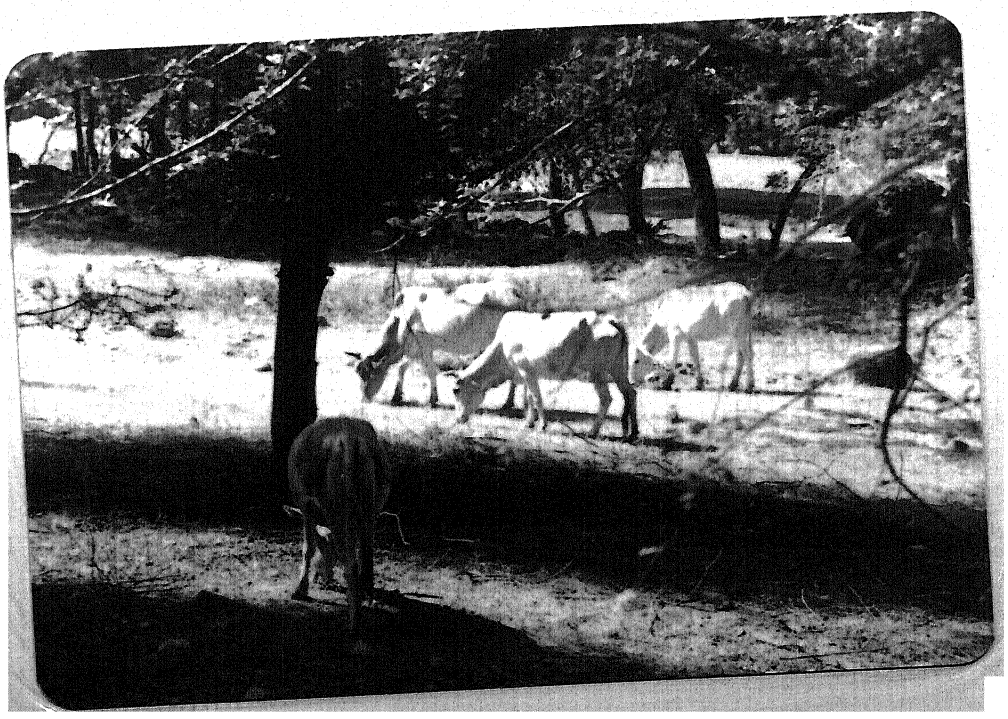
'DEVELOPMENT WITHOUT DESTRUCTION' should be the aim. No development should be at the cost of forest, for without conservation no civilisation would survive. We do want development, not at the cost of our survival but without destruction as asserted by Dr. T.N.Khoshoo, Secretary, Department of Environment and an eminent botanist, "We do not want the DAWN OF TECHNOLOGY to become the SUNSET OF HUMANKIND"[189].

Development and ecological conservation are complementary and not competitive to each other. Irrigation without reference to environment has led to water-logging, acidity in soil and similar other dangers; while hydro-electric generation in certain areas has led to silting of dams, deforestation and lower rainfall causing lesser generation of electricity. Thus, unscientific extraction of natural resources would deplete the biosphere and make human survival difficult.

PLATE - 2. A HIGHLY - SPIRITED BROWSER PARTY PLAYING HAVOC IN THE FOREST.

PLATE - 3. A SUMPTUOUS MEAL OR AN OVERGRAZING OF THE FOREST FLOOR : BEYOND RECUPERATION.





1.5 FOREST FOR OUR SURVIVAL

FOREST is the factory for soil formation and it generates life-gas 'OXYGEN' as its by-product. On hill tops the forest is the inducer of rain which in turn is the mother of all rivers. Basic to flood control and drought control, it is also the reservoir of energy and organic chemicals as well as habitat of medicinal plants. The forest - 'store house of food' is also the foster - mother of agriculture in perpetuity.

Instead of conserving these forests, which are next to none for our existence, we have exploited them wantonly. Inspite of the fact that forest provides fuel for our hearth and wood for our home, we have mercilessly allowed to loiter and to over-graze the forest-floor beyond recuperation by our cattle (Plate - 2 & 3).

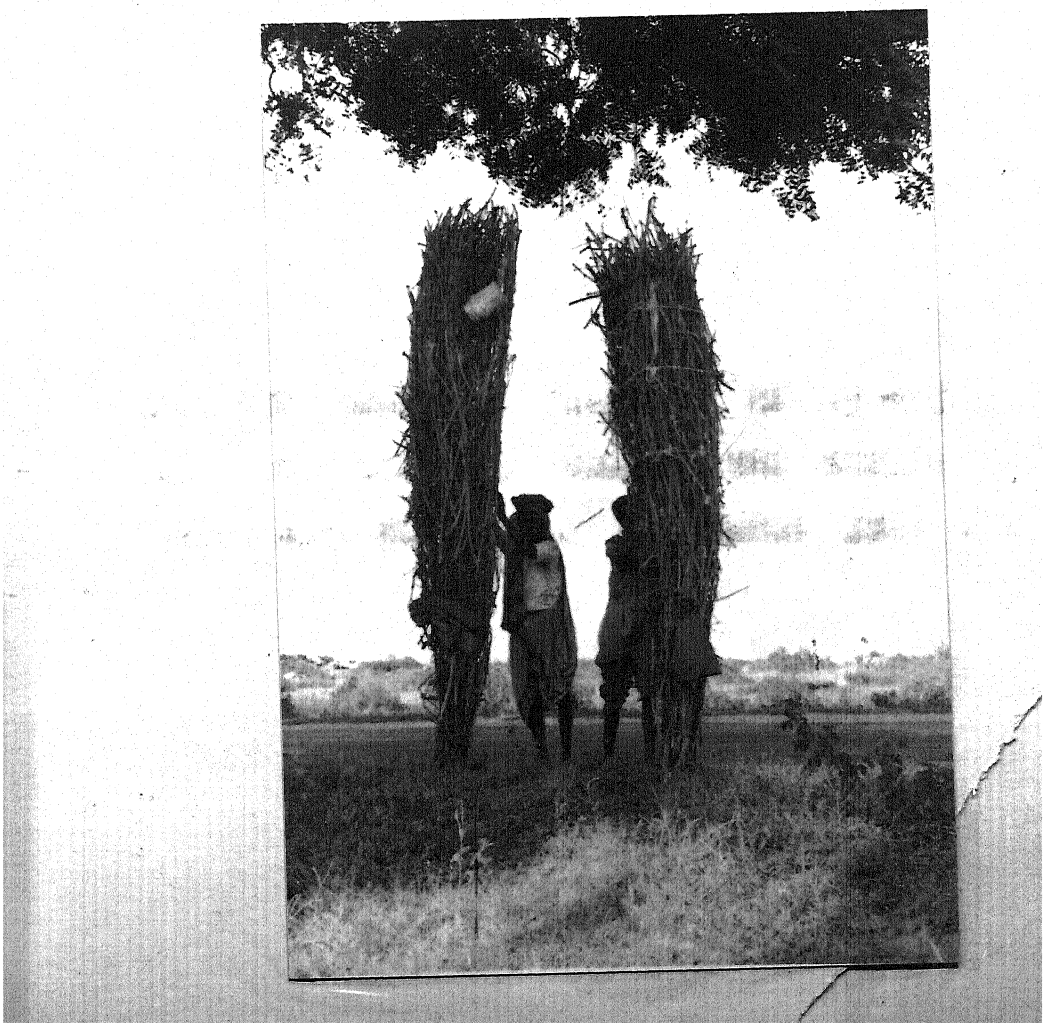
Nature will protect and nurture the man so long as he reciprocates with it. Indiscriminate destruction of Nature's bounty is bound to cause grave consequences. Though, ruthless felling of the forest trees has caused nudity to the environment (Plate - 4), yet proved as a necessary evil for human survival (Plate - 5).

Recently, on Dec. 29, 1986 Dr. M.S.Swaminathan, President of the International Union for Conservation of Nature

PLATE - 4 - WHO WILL PROTECT THE RIGHTS OF PLANTS - ???

PLATE - 5. IT IS EASY TO BLAME THEM FOR DESTROYING THE FOREST; BUT THIS WOOD IS THE ONLY SOURCE OF LIVELIHOOD FOR THEM.





and Natural Resources, while addressing on the occassion of national Environment Congress at Bhopal stated, "The violation of human rights only caused injury to individuals, but violation of human heritage caused an extensive damage to the life supporting system of man."

Hence, only forests can save mankind from the impending disaster. The creation of forests will undoubtedly prove the best ecological antidote against the anthropogenic contamination of the environment.

1.6 C U R R E N T N E E D S

ONCE considered to be rich in forests, India is now specified on the map of the world as 'A DEFICIT ZONE' . Of late Nation is now aware to the supreme need of forests and forestry. Importance of FOREST-ECOLOGY is being realised more and more by Inter-Governmental and Governmental agencies because of the environmental problems created by the depletion of resources, soil erosion, degradation and frequent ecological back-lashes in the form of floods, famine, disease, pollution and other such calamities.

The survey and demarcation of forests; the study of natural regeneration, biotic interferences and the silvicultural characteristics; the study of the germination and growth of tree species have become imperative. New skills are to be generated

in the managerial and technical fields to upgrade the forests. The realisation of the concept of social forestry has also added a new responsibility on the public sector. The welfare of the tribal and other classes of the people below the poverty-line, is yet another equally important aspect of the forestry which rightly deserves a greater attention.

1.7 R E V I E W O F L I T E R A T U R E

FORESTRY is a multidisciplinary approach. It is based on the principles and practices derived from various pure and applied fields that are scattered throughout the spectrum of knowledge. Published bibliographies and indexes to literature help a long way in this respect.

The western countries are well equipped with the knowledge of forestry, but in India no organised dfforts seem to have been made so far for the successful organisation and dissemination of literature on forestry. Several informations are pouring from every corners but availability of their literature is meagre.

However, in order to understand the structure and function of the forest ecosystem, a substantial amount of work has been carried out in our country and is still in progress on tropical forests especially dry deciduous types of Central India 25, 27, 38, 52, 57, 83, 166, 185, 186, 221, 242, 243, 320, 389, 428, 495. These studies have shown the relation of different tree



PLATE - 6. ANOGEISSUS PENDULA TREES GROWING WITH BASE ON THE DRY ERODED GROUND IN ONE OF THE FORESTS OF BUNDELKHAND REGION. IT CAN BE NOTED HERE THAT NO OTHER TREE SPECIES IS SEEN TO MAKE ITS APPEARANCE ON SUCH UNKIND SOILS.



species to their environment, their growth and nutrient cycling, regeneration, effect of fire and other biotic influences on the structure and composition of the forests.

1.8 WHY *ANOGEISSUS PENDULA*?

MANY programmes have been launched and much attention is being paid on the afforestation and reforestation of nude areas of low fertility. It is felt that there is an urgent need to select and develope some economically important forest tree-species that may survive under arid and semi-arid conditions of that region.

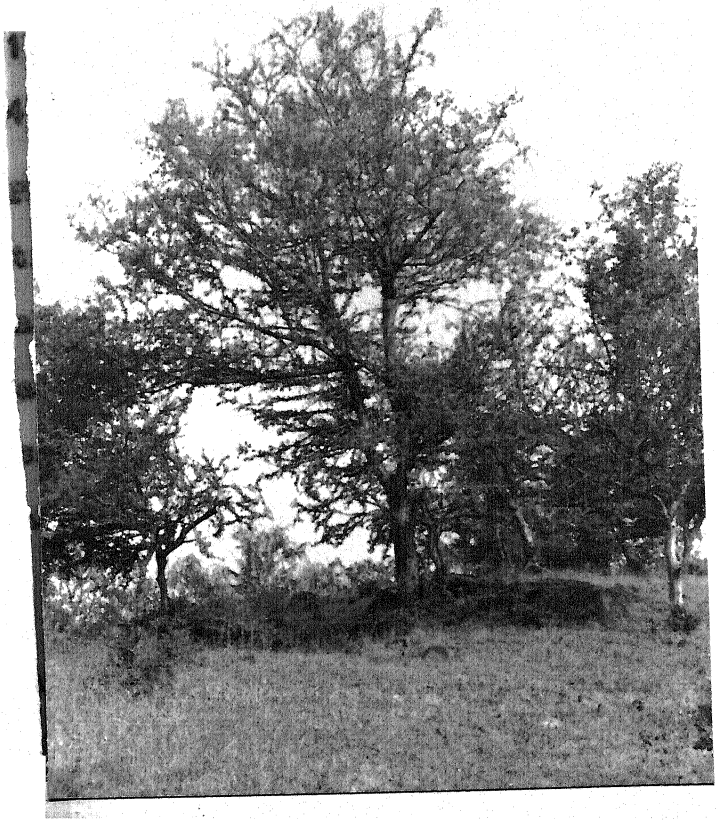
In order to maintain better eco-climatic conditions, the necessity of present study on the structure and reproduction of local forest trees has become very significant, since it is more or less directly connected with the wellbeing of the local people.

One of such tree is *Anogeissus pendula* Edgew., which is locally known as 'KARDHAI'. It is the most dominated tree luxuriantly growing on the dry eroded areas of Bundelkhand region (Plate - 6). Thus, *A.pendula* is well adapted species to the hilly tracts with inhospitable shallow soils where others would fail to survive (Plate - 7 & 8).

In 1963 Sri V.S.Rao, the then Inspector General of

PLATE - 7. NOT A VAUNT, IN FACT THE AMOCARISSUS PENDULA IS VEGETATING AS SAXIFRAGE.

PLATE - 8. AMOCARISSUS PENDULA IN A ROLE OF PAINET, COMMUNICATING A PRACTICAL MESSAGE "THE CONTENTMENT IS HAPPINESS" .



Forests, Govt. of India, in compte rendu of his inspection tour to Rajasthan[338] clearly stated, "ANOGEISSUS PENDULA appears to have a strong will to live." Sri Rao even not hesitated to state, "More attention should be paid in plantation to this STUBBY SON OF THE SOIL."

However, the scientific and ecological work on this important tree is still inadequate [7, 8, 49, 139, 178, 179, 180, 214, 225, 226, 227, 402, 447, 449, 451, 452, 453, 454, 471, 472, 476, 493]; Recently, some more studies on Phytosociology[448, 455] coalition of shoots[450] and roots[366] and tricotylous seedlings[367] of A.pendula have been made. Despite all these studies, some very important aspects on establishment, association with other forest species, root suckers and silviculture of 'Kardhai' have been left over. These studies are still to be worked out.

Due to the low viability of the seeds, the artificial regeneration of 'Kardhai' is very often a problem. Natural regeneration of this species in the heavily grazed areas is all the more difficult. Consequently in 1951 Sri Om Prakash Bhargava - the then M.F.O., Indore, M.P., has very correctly emphasised, "The field is open for research to the students of this species especially in the direction of its artificial regeneration[49]."

1.9 F O S S I L B A C K G R O U N D

THE fossil records of Anogeissus are quite astonishing. The Mio-pliocene epoch of Tertiary period of Cenozoic era in Cuddalore - Series and Tertiary rocks of Pondicherry (South India), exhibited a luxuriant growth of Anogeissus. A form-genus Anogeissusoxylon - very similar to Anogeissus has also been recorded from the vicinity of Pondicherry[277]. Fossil woods resembling Anogeissus acuminata have been collected and recorded from Algeria. This clearly indicates the cosmopolitan distribution of Anogeissus during ut supra Geological time.

'Kardhai' is quite uniform morphologically and it forms an identical forest in a new area. No studies on the racial variations of this species appear to have been done so far. In view of its wide distribution, races are expected.

1.10 P R O P O S E D R E S E A R C H D E S I G N

AFTER considering the above facts, it is thought plausible to develope some new and improved savoir faire for increasing the production and establishment of A.pendula and also for raising the best silvicultural technique and germination behaviour on the lines ut infra :

- Quantitative and qualitative assessment with special reference to the ground flora in order to understand the nature

of relationship between A.pendula and the other plant species.

* Physical characterics of 'Kardhai' seeds in relation to various local sites of their collections. This will certainly help in sorting out the healthy and more viable seeds for future.

* Effects of various pre-sowing treatments on germination behaviours of A.pendula seeds.

* Nursery techniques in order to assess the effects of different external and internal factors on the pattern of growth performances during initial stages of establishment of A.pendula.

* Pattern of natural regeneration particularly through root-suckers, which has hitherto very much neglected by the previous workers.

* Silvicultural treatments with special reference to regeneration through cuttings and sucker plantations.

*****

C H A P T E R - II

STUDY AREA AND THE CLIMATE

C H A P T E R - II

S T U D Y A R E A A N D T H E C L I M A T E

2.1 P R E M I S E

JHANSI, the famous city of 'MAHARANI LAXMI-BAI' needs no introduction. Her martyrdom paved the path for freedom, the fruits of which are being enjoyed by the country-men without which the present work could not have been dreamt of , because in the clutches of slavery one had no right to select his career and to contribute to the fosterage of the Nation. The era of freedom ushered into new avenues for research, hence, the present work.

Jhansi district is the headquarters of Bundelkahand region of Uttar Pradesh. Geographically it is situated between 25°10' N -25°32' N latitude and 78°18' E - 78°45' E longitude and is about 275 m above the mean sea level. Jhansi is surrounded by Madhya Pradesh on three of the four sides (Fig. -2.1).

The forest vegetation of Jhansi and its adjoining area is transitional between the Southern tropical dry deciduous type and the Northern tropical dry deciduous type. The different forest-types of Jhansi along with their distribution, general floristics and other characteristics are discussed in Table -2.1. Forests in Jhansi region cover only 6.48 percent of its total geographical area and the per capita forest area is

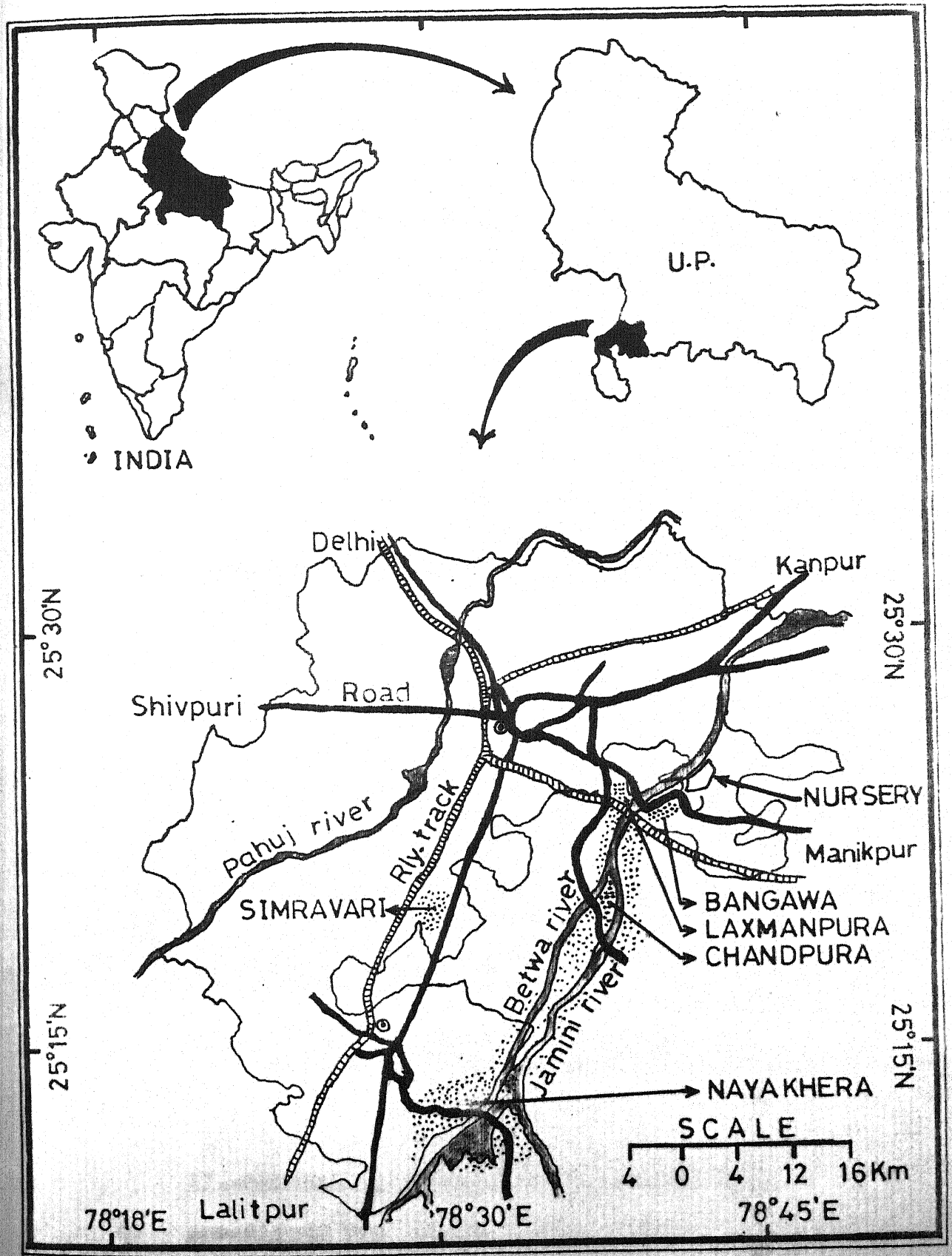


FIG. 2.1 MAP OF THE STUDY SITES.

TABLE - 2.1 DISTRIBUTION, FLORISTICS AND OTHER CHARACTERISTICS OF THE FOREST-TYPES PRESENT IN AND AROUND JHANSI.

S.No.	TYPE OF FOREST	SUB-TYPE*	LOCATION AND OTHER CHARACTERISTICS	F L O R I S T I C S
	I. RESERVE FORESTS			
1.	Tropical riparian forest	4E/R.S.-I	These are post-climax forests occuring along the river banks of Betwa	Bauhina vahlii, Butea superba, Carissa spinarum, Eugenia heyniana, Flacourtia indica, Gardinia turgida, Helicteres isora, Mallotus phillipinensis, Manilkara hexendra, Mitragyna parviflora, Terminalia arjuna, Ventilago calyculata, Vitex negundo, Woodfordia fruticosa, etc.
2.	Dry Teak forests	5A/C-1(b)	Isolated patches near the banks of river Betwa	Anogeissus latifolia, Carissa carandas Diospyros tomentosa, Ichnocarpus frutescens, Lagerstroemia parviflora, Lannea coromandelica, Mucuna pruriens, Sterculia urens, Tectona grandis, Terminalia arjuna, Zizyphus nummularia and Zizyphus oenoplia etc.
3.	Southern-Northern dry mixed deciduous forests	5A/C-2 & 5B/C-2	This type occurs on the plains notth of Vindhyan highland in Talbehat and Jhansi ranges	Balanites aegyptiaca, Bridelia retusa, Carissa carandas, Combretum decandrum, Cryptolepis buchanani, Helicteres isora, Holoptelia integrifolia, Ichnocarpus frutescens, Lannea coromandelica, Nystanthes arbor-tristis Pterocarpus marsupium, Securinega virosa, Zizyphus mauritiana, Zizyphus nummularia etc.
	II. GENERAL EDAPHIC TYPE			
4.	Anogeissus pendula forests	5B-1	This type occurs on	Abrus precatorius, Acacia catechu, (Continue)

(Continued) -

			quarts ridges, hillocks and plains in Bangawa, Ghaisauli, Mankua, Simravari blocks of Jhansi ranges with almost pure patches of 'Kardhai'.	Anogeissus pendula, Bauhinia racemosa, Butea monosperma, Carissa carandas, Lannea coromandelica, Myrsine africana, Nystanthes arbor-tristis, Ventilago calyculata, Vitex negundo, Zizyphus mauritiana, Z. nummularia and Z. oenoplia etc.
5.	Anogeissus pendula scrub forests	5B-1/DS-1	This type occurs where the conditions are extremely adverse due to biotic influences. A.pendula is reduced to shrub. Common in Athothena, Palinda & Rasoi of Jhansi ranges.	Acacia catechu, Barleria strigosa, Bauhinia racemosa, Butea monosperma, Carissa spinarum, Ipomoea pes-tigridis, Lantana camara, Rhus mysorensis, Trichosanthes cucumerina, Zizyphus nummularia and Zizyphus xylopyrus etc.
6.	Boswellia forests	5B-2	Saiyyar and Sijuaha blocks of Jhansi range and in the ravines flanking the river Pahuj.	Acacia catechu, Acacia leucophloea, Boswellia serrata, Lagerstroemia parviflora, Lannea coromandelica, and Sterculia urens etc.
7.	Butea forests	5B-5	On badly drained clay soils in valleys, hillocks and along the river banks in Bamaura-ghurra, Bijapur and Seikkar blocks of Jhansi range with open canopy.	Acacia catechu, Butea monosperma, Carissa carandas, Lagerstroemia parviflora, Wrightia tinctoria and Zizyphus nummularia etc.
8.	Ravine thorn forests	6B/C-2	Confined to ravinous area in patches along the river Betwa. Can is always open and characterised by ari conditions.	Acacia catechu, Acacia nilotica, Capparis decidua, Capparis zeylanica, Carissa carandas, Dichrostachys cinerea, Flacourtia indica, Prosopis spicigera, and Zizyphus nummularia etc.

* From Champion and Seth, 1968. Courtesy of Govt. of India Publ., New Delhi 77.

only 0.037 (429).

2.2 S T U D Y S I T E S

FOR phytosociology and other studies, six blocks of Anogeissus pendula dominated forests were selected after preliminary survey of the whole region. Details of all these six sited are ut infra :

SITE - I : BAMANA FOREST of Jhansi range. This forest is situated on the eastern side of Jhansi - Mauranipur road and is nearly 13 Km from Jhansi. About 180.70 ha area of the forest is reserved and in general the forest is tropical mixed dry deciduous type.

SITE - II : CHANDPURA FOREST of Tikamgarh range. This forest is situated on Jhansi - Tikamgarh road near Orchha (M.P.), Anogeissus pendula forms a pauras pure crops, often quite well stocked.

SITE - III : LAXMANPURA FOREST of Tikamgarh range. This forest is situated on either sides of the Orchha - Barwasagar rail tract, running from Orchha railway station to the railway bridge over river- Betwa. It is about 13 km from Jhansi by road. The natural growth of

The natural growth of trees in this forest has been mostly destroyed.

SITE - IV : SIMARVARI FOREST of Jhansi range. This forest is situated on the western side of Jhansi - Lalitpur highway. It is about 18 km south of Jhansi. The forest comprises of pure and protected patches of A. pendula. Biotic disturbances are comparatively less except occassional lopping of the trees by a small number of villagers. Rodents and birds are relatively too much.

SITE - V : NAYA-KHERA FOREST of Talbahet range. This forest is situated near Sukwan-dukwan water reservoir and is nearly 40 km away from Jhansi via Babina.

SITE - VI : JHARAR FOREST of Talbahet range. This forest is about 40 km from Jhansi on Jhansi - Lalitpur highway. It is situated on the eastern side of the road and is in north of the river Betwa near Jharar-ghat.

All these sited are depicted in Fig. -2.1.

2.3 NURSERY

FOR germination, seedling growth and silvicultural studies the author made use of the Bangawa forest nursery with due permission of the forest department Jhansi. The nursery is situated on the eastern bank of the river Betwa and is about 15 km from Jhansi on Jhansi - Mauranipur road.

2.4 EDAPHOLOGY

SOIL is by far the most important single factor controlling the distribution, composition, production and quality of forest-tree. Anogeissus pendula appears to occur on sites relatively poor in C/N ration (10 or less) than that for A.latifolia. Both these species are found to occur in soils having a pH of 6.3 and 6.5 respectively[395].

The soils of the region in general are poor in nitrogen, low and medium in phosphate and medium to high in potassium[157].

Many a times different soils occur in a small area giving a typical mosaic appearance. These soils are broadly grouped in Red, and Black soils and are further classified into Rakar, Parwa, Kabar and Mar soil series on the basis of their texture and colour[223].

The soils of the area reflect the following patterns[3].

(1) Red soils in hilly portions giving an eroded appearance.

(2) Brown soils rich in $CaCO_3$ and gravel layers found on level plains and uplands near catchment areas.

(3) Black and plain soils with high percentage of clay on low lying areas under restricted drainage.

Chemical properties, moisture retention characteristics and fertility status of the soils are provided in Tables - 2.2(a), 2.2(b) and 2.2.(c) respectively.

Bundelkhand soils are residual in nature and are formed *in situ* from the parent material in general. Red soils are originated from the parent rocks like gneiss and granite. Some times they are also formed from sand stones. Black soils in contrast are formed partly *in situ* and are partly transported. The parent material for black soils is lime stone and trap. Rock minerals of the parent material of Bundelkhand soils are comprised of Quarts, Feldspar, Hornblende, Chlorite and Mica. Dominant soil forming factors besides parent material, are topography and climate[223]. Soil map of Jhansi is provided in Fig. - 2.2.

2.5 T O P O G R A P H Y

The region is covered with Vindhayan ranges running East to west and presenting undulating plains which are relieved at places by rocky hills or ravine-edged river beds. The tract presents an undulating terrain with rocky

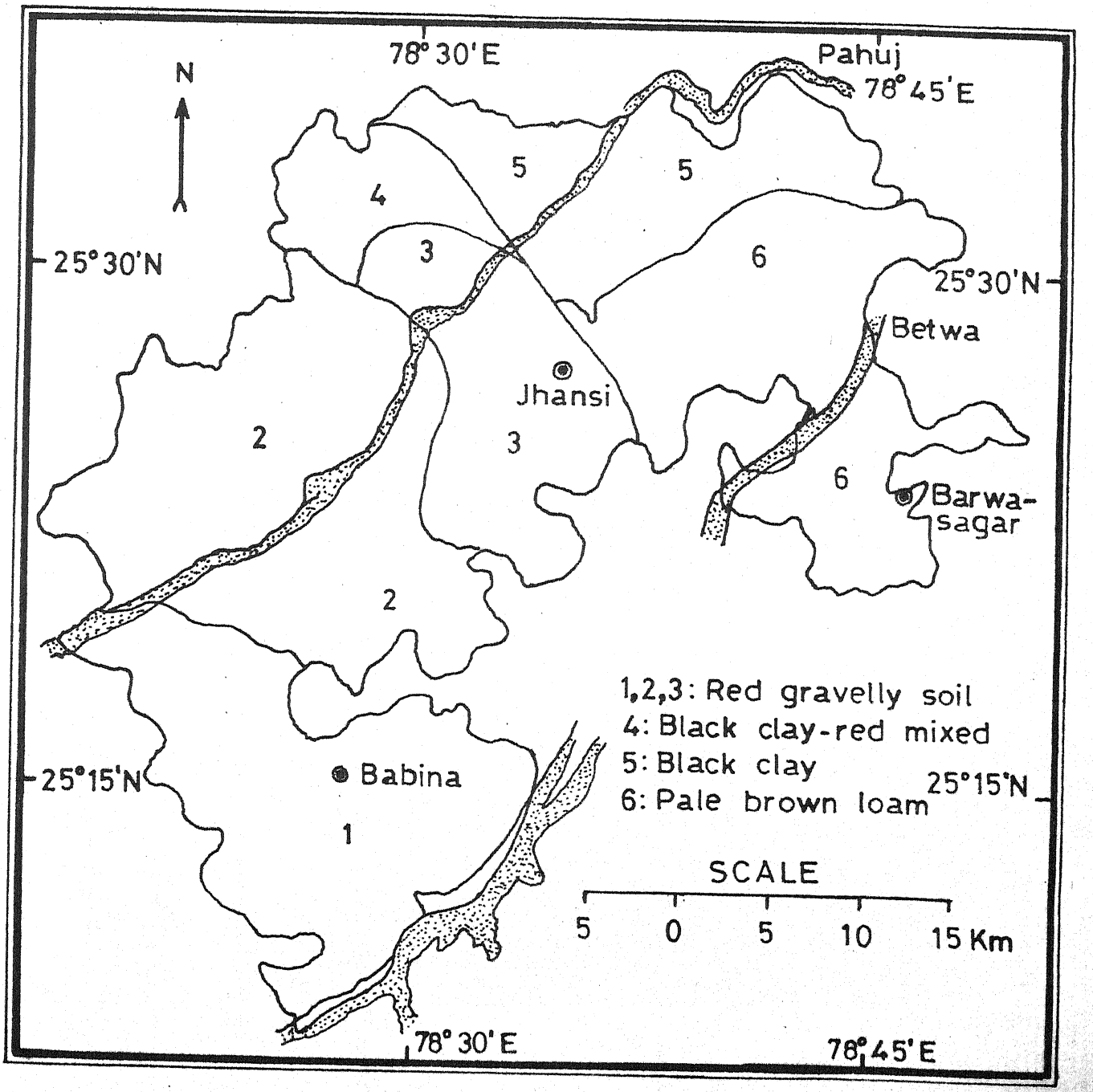


FIG. 2.2 SOIL MAP OF JHANSI AND ITS SURROUNDINGS.

TABLE - 2.2.(a) CHEMICAL PROPERTIES OF RED AND MEDIUM BLACK SOIL

(From Hasra, 1981; Courtesy of Indian J. Agric Management) 157.

SOIL DEPTH	pH	TOTAL SOLUBLE SALT (%)	ORGANIC C. (%)	TOTAL N. (%)	AVAILABLE P. (kg/ha)	AVAILABLE K. (kg/ha)
0 - 15	7.0	0.014	0.46	0.04	9.4	160
	(7.2)	(0.020)	(0.65)	(0.06)	(12.8)	(220)
15 - 30	7.1	0.018	0.39	0.03	8.0	140
	(7.5)	(0.022)	(0.49)	(0.04)	(9.6)	(190)

Note : Figures in parenthesis are of medium black soil otherwise of red soil

TABLE - 2.2.(b) MOISTURE RETENTION CHARACTERISTICS OF DIFFERENT SOIL - TYPES OF BUNDELKHAND.

(From Hasra, 1981; Courtesy of Indian J. Range Management)[157].

SOIL - TYPE	FIELD CAPACITY(%)	WILTING POINT(%)	AVAILABLE WATER CAPACITY (cm)*	PERMEABILITY (cm/hr)
Red soil (Rakar)	8.5 - 13.0	4.0 - 5.5	4.4 - 6.0	6.0 - 12.6
Mixed red & black (Soil parwa)	14.0 - 18.0	5.4 - 7.5	11.7 -14.2	1.4 - 3.2
Medium black soil	19.0 - 32.0	8.0 -15.0	18.5 -26.9	0.5 - 1.0

* - Profile moisture of effective soil depth of 60, 90, and 120 cm red, mixed red, and black and medium black soil respectively.

TABLE - 2.2.(c) FERTILITY STATUS OF BUNDELKHAND SOILS.

(From Mannikar, 1991; Courtesy of Indian J.Range Management)[223].

SOIL SERIES	FERTILITY STATUS (RANGE)*		
	NITROGEN	PHOSPHORUS	POTASH
Rakar	L - MH	L - M	L - MH
Parwa	L - M	VL - M	M
Kabar	L - M	VL - L	L - MH
Nar	M	L	M

* LEGENDS : VL = Very low, L = Low, M = Medium, MH = Medium High

out-crops here and there (plate - 6) with considerable variation in the types of soil, its colour, texture and depth etc.

The topography of the region lies within 300 m above mean sea level in general and exceeds over 450 m in some cases. The hypsometric curve of the region shows that about 67.7 percent of the area is under 300 m and 28.7 percent lies between 300 and 400 m with small area (3.6 %) above 450 m.

Betwa, Pahuj and Jamini are the main tributaries of the river Yamuna, flowing through the tract. The bank of these river are flanked by most of the forests of the region.

2.6 C L I M A T E

THE climate of the region can be described as semi arid with Longs's rain factor 41.9 mm/°C. Centrality of the region imposes on it the features of a transitional climate between the maritime of the East coast (Bay of Bengal) and the tropical continental dry type of the west (Rajasthan). The tract is characterised by a long and intensely hot summer, low and irregular rainfall and short chilly winter.

2.6(a) R A I N F A L L

THE year 1986 and 1987 experienced total 739.1 mm and 828.2 mm rainfall distributed over 45 and 43 rainy days respectively which were 21 and 11.5 percent below the average rainfall (936 mm) of the region. Moreover, the number of rainy days were not well distributed.

The year 1986 experienced normal onset of monsoon in the 3rd week of June (25th standard week) but very early withdrawl of it in mid - of the August (33rd standard week). Thus, hoc anno the monsoon was effective for 8 weeks and only 559.1 mm rains were available during the season as against the normal rainfall of 870.5 mm. In winter only 26.4 mm rains were recieved in 3 rainy days.

The year 1987 experienced late onset of monsoon which started in the 1st week of July (27th standard week) and broke for a continuous period of 3 weeks (29th to 31st)standard week). Then again the rains were not well distributed though the monsoon continued upto the 3rd week of September (38th standard week). Hoc anno only 619 mm rains were received in 12 weeks with 2 major breaks as against the normal rains of 870.5 mm (Table - 2.3)

Thus, about 90 percent of the total precipitation was recieved between mid of the June and the end of the September. There were occassional showers during winter months. The distribution of rainfall was often erratic and even the wet months i.e., July and August experienced long dry spells.

2.6(b) T E M P E R A T U R E

MEAN annual temperature of the region is 26.5°C. May and June are the hottest months and record maximum temperature of 43°C to 47°C whereas, the minimum temperature

TABLE - 2.3 AVERAGE MONTHLY CLIMATIC CONDITIONS OF JHANSI DURING THE STUDY PERIOD (1986 - 1987).

(From Pradeep Bihari, Courtesy of Indian Grassland and Fodder Research Institute, Jhansi)

MONTHS		TEMPERATURE °C		RELATIVE HUMIDITY		RAIN FALL	
		MAXIMUM	MINIMUM	PERIOD - I	PERIOD - II	mm	RAINY DAYS
January	A-	21.5	5.5	79	41	38.4	5
	B-	24.4	7.2	71	28	8.7	2
February	A -	24.2	10.5	87	42	81.3	5
	B -	30.3	11.2	72	23	22.9	3
March	A -	33.5	15.5	71	22	14.8	1
	B -	35.0	17.0	60	18	9.2	1
April	A -	40.2	22.8	49	17	1.2	-
	B -	40.8	22.2	45	11	-	-
May	A -	41.7	24.1	45	16	17.8	3
	B -	42.8	25.5	44	14	6.7	2
June	A -	40.1	28.9	49	24	151.6	7
	B -	44.2	29.8	53	28	3.6	1
July	A -	32.5	24.5	80	56	275.6	15
	B -	38.1	26.3	70	43	219.4	9
August	A -	33.5	24.6	77	46	97.5	4
	B -	35.3	25.8	83	58	146.0	12
September	A -	35.4	23.5	71	40	27.5	2
	B -	33.3	23.7	83	50	266.3	10
October	A -	33.2	17.4	71	38	23.8	2
	B -	33.9	18.1	72	36	119.9	2
November	A -	29.6	10.5	72	26	-	-
	B -	30.1	9.7	73	29	-	-
December	A -	24.1	6.8	74	80	2.6	1
	B -	24.8	6.6	84	34	35.5	1
ANNUAL	A -	32.46*	17.72*	68.75*	33.17*	739.1	45
	B -	34.42*	18.59*	67.5*	31.0*	828.2	43

LEGENDS : A = 1986, B = 1987

* = Mean annual

reaches 4°C to 5°C during December and January with reports of occassional freezing temperature.

During 1986, the highest temperature of 45.7°C was recorded on 11th of June and the lowest of 3°C was noticed on 21st of December. The year 1987 experienced highest of 47.4°C temperature on 8th of June and lowest of 2.5°C as recorded on 8th of December.

The summer usually begins by about the middle of March, extends upto the end of June and ends with the onset of monsoon. The severity of the heat during day time is aggravated by strong-hot and generally dustless westerly winds which blow throughout May and June and is characterized by comparatively clear and dustless sky.

On the basis of moisture index, Jhansi has been considered semi-arid eco-climatically with moisture index ranging from - 40 to - 60. In all, the region is subjected to steep slopes, quick run-off, erratic and scanty rainfall, periodic dry spells and unfavourable geology.

2.6(c) O M B R O T H E R M I C D I A G R A M

THE effectiveness of climatic factors like rainfall and temperature give a better understanding of wet and dry periods and can be well understood in a better way with the help of Ombro-thermic diagram[127]. These ombro-thermic curves have been presented in Fig. - 2.3 for the study period.

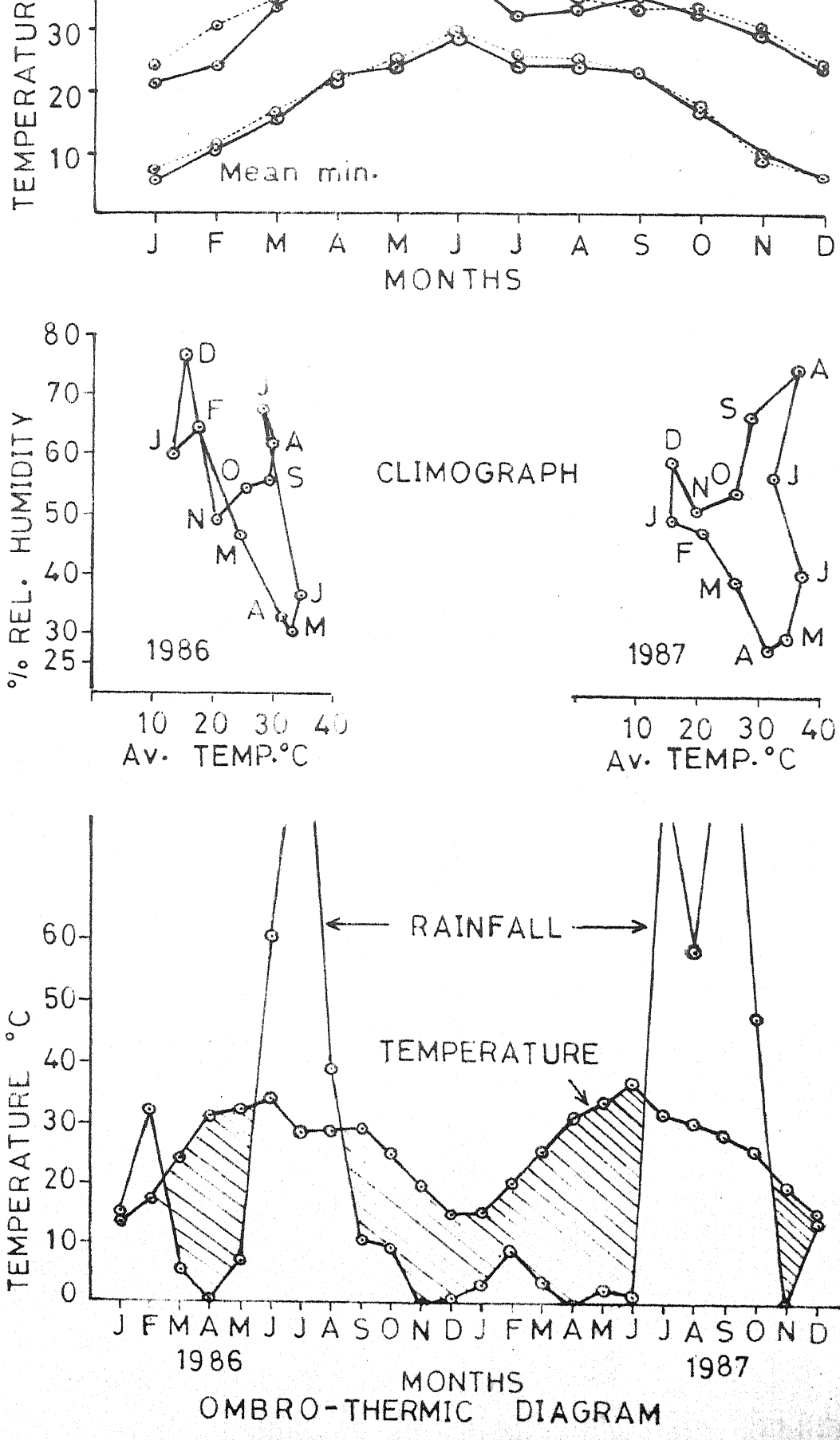


FIG. 2.3 CLIMATIC CONDITION OF JHANSI (1986-1987)

Perusal of the curve indicates that on an average more than nine months were dry (September to June) when the thermic curve remained above the ombric curve, whereas, in rest of the months ombric curve exceeded the thermic curve attributing wet nature to these months.

2.7 B I O T I C I N F L U E N C E S

LOCAL needs from the forests of Jhansi and its adjoining area are grazing, fodder, firewood, agricultural implements, timber, thorn and bushes for fencing etc. The low productivity of these forests as reels their current misuse due to over-grazing and human interference call for a need to think about their improvement.

Man and his tamed animals have a big influence on the vegetation of these forests in its various stages of development (plate 2& 3). Men exert a profound influence by cutting, stripping and felling of the seasonal and perennial vegetation (plate - 4 & 5).

Branches are lopped. Monkeys and 'Langoors' often break the leading shoots. Sheep, goat and cattle affect the vegetation due to extensive and uncontrolled browsing and grazing causing considerable damage to the young seedlings, coppice shoots and saplings. Burrowing animals and reptiles e.g., snakes and rodents etc., while making their burrow

cause death to the perennial plants by exposing their roots. All these and other factors have contributed to the declining productivity of the forest at an alarming rate.

Fire, used for pleasure, for pestering the neighbours, for clearing the land, for making the land passable, for converting forest into pastures and so on, has played havoc with the forest. These periodic burnings have led to the development of bare grasslands or bare areas that are scattered over the forest land. Frequent jungle fires have also resulted in the invasion of exotic, fire-tolerant, ubiquitous weeds such as Lantana Camara and many others.

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C H A P T E R - III

DESCRIPTION OF THE VEGETATION

C H A P T E R - III

D E S C R I P T I O N O F T H E V E G E T A T I O N

3.1 P R E M I S E

Forest is a multitiered structure in which trees constitute the top or emergent layer while the floor vegetation the lower most or ground layer. The upper and lower layers are intergraded with a number of other layers i.e., sub-canopy, shrubs, under-shrubs, climbers, creepers, twinners, herbs and grass etc. These different vegetational layers provide heterogenity to a forest[365].

Vegetation of any area is more than the mere grouping of individual plants. It is the result of the interaction of numerous factors[482]. The part played by vegetation in the hydrological cycle by intercepting the rainfall reducing the velocity of rain drops while falling through its canopy, providing a cushion on the soil surface and reducing the velocity of run-off etc., are extremely important in conservation of water and the soil.

The knowledge of floristic composition, qualitative and quantitative characteristics is all the

more important in managing the forest ecosystems. The study of floristic composition in quantitative terms may provide the answers to reveal the mystery of the complex dynamics of the ecological changes that has been taking place in space and time.

Kershaw[183] has rightly stated, "The floristic composition, simply expressed as a list of species, life-form composition and structure of vegetation are a necessary basis of all ecological work; this approach to ecology has dominated the structure until quite recently and will continue to be prominent till an adequate description of all vegetation both on a regional and on a world-wide basis is completed."

According to Oosting[291], "The first and foremost objective in ecological work is to learn the composition and structure of the community under consideration. Then, and only then, logically follows a search for causes, experimentation and interpretations based upon a firm foundation."

3.2 R E V I E W O F L I T E R A T U R E

VEGETATIONAL analysis is important as the structure of the vegetation expresses most relevant results and is a flexible tool in the analysis of complex system. European workers, who first used the term 'PHYTO-SOCIOLOGY' have long been interested in detailed structure, precise location, description and systems of classifying communities. As a result,

the term phytosociology has frequently been reserved for such studies[291].

In India, the phytosociological studies were initiated by F.M.Bharucha and his students especially with reference to the biological-spectrum of Matheran and Mahabaleshwar flora[51]. Since then, various phytosociological techniques have been employed to study the different forest communities and their relationships[27, 84, 85, 128, 169, 170, 173, 196, 238, 334, 381, 386, 397, 414, 448, 455, 502].

Recently, some phytosociological and floristic studies of herbaceous undergrowth in some forest habitats of India have been carried out viz., Association of forest floor of Pinus roxburghii in Garhwal Himalayas[170]. Herbaceous undergrowth in some forest habitats in Nilgiris[329]. Floristic composition of Chandpura forest (mixed dry deciduous type) dominated by pure patches of Anogeissus pendula[363]. Seasonal variations in herbaceous layer in a mixed dry deciduous forest stand near Jhansi[368], grass production under Cedrus deodara forest in Himachal Pradesh[405], etc.

Some other related studies made on the herbaceous vegetation of forests are : Performance of ground flora under desertic communities of trees[142]; herbaceous layer of Patharia

forest in relation to tree cover, soil and topography at Sagar[221]. Comparative account of ground cover and undergrowth of 'Sal' forest and Eucalyptus plantation in different localities of Doon valley[228, 229, 328], herbaceous vegetation of Bundelkhand forest division of Jhansi[457], etc.

The life-form is assumed to have evolved in direct response to the climatic environment and accordingly their proportions in an area gives a good indication of its climatic zone[183]. The Raunkiaer's system of life-forms and biological spectra with various later improvements has been widely applied to compare numerous floras in the world and in different regions of India viz., grassland association near Bombay[50], Matheran and Mahabaleshwar[51], Indian desert flora[104], grasses and grassland in Jhansi district[175], Sirwell Hills, Madhya Pradesh[218], arid and humid tropics[235], foot-hill zone of Central Himalayas[237], reserve forest near Bhavnagar[301], Khoh valley of district Pauri Garhwal[330], Karamnasah water shed, Varanasi[337], Mathura district[394], Allahabad[426, 470], marshy grassland at Rajpur-Dehradun[427], Koleras range near Shivpuri,[466] M.P. Lobab-valley, Kashmir[477], etc.

Thus, a thorough knowledge of the community can be helpful in understanding the ecological implications of the forest and thus can furnish needful information for their management. However, no significant contribution appears to

have been made on the forest flora of Bundelkhand in general and Jhansi in particular. Till date, we have no published flora of Jhansi. There are but a few partial lists, otherwise the region has scarcely been studied[230, 302, 321, 395, 429, 443, 445, 457]. Very recently, the author had made contribution in the study of floristics of some local forest areas as a part of the present work[363, 364, 365, 368]. any way, the region is still awaiting publication of a general flora.

3.3 M A T E R I A L A N D M E T H O D

MENTION may be made here, that the earlier studies on forest phytosociology could not explain the inter-specific relations between herb layer and tree vegetation of a forest community. Very little, say almost negligible attention was paid on such relations. The herbaceous flora was either completely overlooked or the work was done only in name.

In the instant study, a bold bid has been made to propose, preferably for the first time, to work out such relations between trees and ground flora at different sites to attain results and new heights.

Five locations were selected in five different blocks of *Anogeissus pendula* dominated forests in and around

Girth at breast height (gbh) and approximate height of each individual tree encountered was recorded. Minimum gbh and the height of the tree taken into consideration was 15 cm and 3 m respectively.

The pooled vegetational data were quantitatively analysed for obtaining density, frequency and basal area of the species[96]. To assess the dominance of the component species and to arrive at a floristic association, the relative values of frequency, density and basal area (abundance) were computed for calculating Importance Value Index (IVI)[309] ut infra :

I.V.I. = Rf + Rd + Rb

where, I.V.I. : Importance Value Index,

Rf : Relative frequency,

Rd : Relative density, and

Rb : Relative basal area (abundance)

$$Rf = \frac{\text{Frequency of a species}}{\text{Sum of frequency values of all species}} \times 100$$

$$Rd = \frac{\text{Density of a species}}{\text{Sum of density values of all species}} \times 100$$

$$Rb = \frac{\text{Basal area of a species}}{\text{Sum of basal area of all species}} \times 100$$

Ad recte, the ratio of abundance to frequency

(A/F) of all species was worked out to interpret the distribution pattern of the species[433]. The values of A/F < 0.025 indicate irregular, 0.025 to 0.050 indicate random and > 0.050 indicate contagious distribution[95]. Community co-efficients between all forest sites were determined for comparing the vegetational and floristics of the sites[165] as below :

$$C.C. = \frac{2W}{a - b} \times 100$$

where, C.C. : Community co-efficient,

a : frequency values of all species in site a,

b : frequency values of all species in site b, and

W : frequency values of all species common in sites a and b.

Index of similarity between two communities were calculated by making use of the following formula of Sronsen[237].

$$S = \frac{2C}{A + B}$$

where, S : Index of similarity,

A : Number of species present in stand A,

B : Number of species present in stand B, and

W : Number of species common to both A and B.

Index of dissimilarity = 1 - S

For ground vegetation, 50 quadrats of 1 m x 1 m size were studied in each of the five sites already mentioned. For the sake of convenience, the phytosociological studies of small quadrat was studied in each of the large quadrat by random method. The component species present in small quadrats were quantitatively analysed in the same manner as of trees.

3.3(b) J A I - S U L M O D E L

RECENT trend in vegetation ecology is to process the field data through mathematical equations for deriving the community structure. Importance of sampling a plant community so as to obtain maximum amount of information from one set of samples, has been emphasized by numerous workers[69, 120, 138, 183, 224, 261, 316, 340, 424, 435, 483, 490].

Generally girth (gbh) and height of each individual is recorded and the data are quantitatively analysed for obtaining density, frequency, basal area or abundance etc., of the species. Relative values of these are computed for calculating Importance Value Index[96, 309], association co-efficient is calculated for the significantly associated species[90]; tree species diversity for different forest types is determined by using Shannon-Wiener information function[383]; Simpson's index is used for measuring concentration of

dominance[393]; the ratio of abundance to frequency is worked out to interpret the distribution pattern of the species[438]; etc.

All these systems of analysis and statistical formulae give only an idea of the composition and quantitative structure of the community under consideration. Unfortunately, none of the workers has paid attention in developing a system of analysis to determine the productive quality of a species or a forest as a whole.

However, mensurationists from time to time, have advocated various models for estimating stand basal area growth and yield of different species e.g., Pinus resinosa[68], Pinus taeda[89, 436]; Pseudotsuga menziesii[97]; Pinus contorta[101]; mixed hardwords[250] and Pinus elliottii[306, 312, 313], etc. In addition many growth and yield models exist in forestry literature[475, 493].

Cao, Burkhart and Max[72] evaluated two methods of estimating merchantable volumes to specified top diameter or height limits. Curtis[98] compared height-diameter-age and height-diameter equations for second-growth douglas fir. Ek[111] using simulation techniques, evaluated 12 height-diameter and height-diameter-age models for small samples. Furnival[124] proposed an index to compare tree volume equations. Newnham[279] modified the combined variable formula and then compared it to

the logarithmic formula and unmodified version of the combined-variable formula using single tree volume data from eleven species. Mokoe[283] carried out a comparison between nonlinear models which were fitted to volume-age data. Pichi-Sermolli[310] developed an index for establishing the degree of maturity in plant community. Sadiq[353] observed the graphs of stand basal area growth and yield with some correlated variables and exhibited reverse logistic trends with the exception of site-index. Spurr[425] evaluated various yield equations for data from different species. Yang, Kozak and Smith[504] proposed a modification to Weibull function and then, employing height-age data from a single tree and data from two polymorphic stand volume-age curves, compared its predictive power with some well known growth functions like von Bertalanffy, Mitscherlich, Logistic and Gomperts.

Since basal area is a preferable estimator of stand growth[425], coupled with the fact that no evidence of productive quality of a species or a stand as a whole exists in published literature, such an evaluation, therefore, seems desirable. Hence, through this presents, a simple, genuine and reliable eco-mathematical model has been devised for determining the various levels of productive quality of trees, both as a species and collectively as a forest. This model,

which cover ups the deficiency in qualitative assessments, hereafter, has been termed as 'JAI-SUN MODEL'[369] and can be formulize ut infra :

$$\text{JAI-SUN VALUE} = \frac{\Sigma\, b_x}{T_i}$$

where, $\Sigma\, b_x$: Sum of basal area (m^2) of every individuals of x species assessed.

T_i : Total number of individuals of the x species assessed.

The term 'JAI-SUN' has been coined by combining first vowel of two names. 'JAI' has been derived from the name of honourable supervisor Dr. Jai Prakash Tripathi, M.Sc., Ph.D., Department of Botany, Bipin Bihari College, Jhansi (U.P.) and 'SUN' has been derived from author's name.

Since plants with minimum 15 cm gbh are considered as tree, the lowest limit of the value, as determined by this formula of the model, will arrive as low as 1.79×10^{-3}. However, the upper limit will depend upon the health of a tree. Considering these two i.e., the upper and the lower limits, values arrived at are arranged in an index of four different categories viz., A, B, C and D. These categories in turn were further differentiated into two levels each. Thus, eight levels of health or productive qualities are formed ut infra :

A^+ = Excellent,

A = Superior,

B^+ = Very good,

B = Good,

C^+ = Fair,

C = Satisfactory,

D^+ = Poor, and

D = Very poor.

By comparing the Jai-Sun values, as derived by the formula, of a species with that of 'Jai-Sun Index' (Table - 3.1), one can very easily assess the average health or quality of the concerning tree species or of all species separately present in a forest.

EXAMPLE : Suppose there are three species of trees x, y and z present in a stand with 39, 4 and 7 individuals respectively. And if the sum basal area (m^2) of these individuals of the three species, as assessed, are : 0.3042 m^2/spe.-x, 0.2668 m^2/spe.-y, and 0.2016 m^2/spe.-z; the Jai-Sun values of them can be determined as below :

$$\text{Jai-Sun Value} = \frac{\Sigma b_x}{n_i}$$

$$\text{J-S V for spe. x} = \frac{0.3042}{39} = 0.0078$$

TABLE - 3.1 'JAI-SUN INDEX' FOR DETERMINING THE EIGHT DIFFERENT LEVELS OF PRODUCTIVE QUALITY OR THE HEALTH OF THE TREE SPECIES IN A FOREST STAND.

S.No.	JAI-SUN INDEX		
	VALUES	QUALITY	LEVEL
1.	< .005	Very poor	D
2.	.005 to .015	Poor	D^+
3.	.015 to .025	Satisfactory	C
4.	.025 to .035	Fair	C^+
5.	.035 to .050	Good	B
6.	.050 to .075	Very good	B^+
7.	.075 to .100	Superior	A
8.	> .100	Excellent	A^+

$$\text{For Spe. } y = \frac{0.2668}{4} = 0.0667$$

$$\text{For Spe. } z = \frac{0.2016}{7} = 0.0288$$

On comparing these Jai-Sun values of the species with that of the values provided in the Jai-Sun Index (Table - 3.1), an average health or quality of the species can be known. Thus, the health of Spe.-x is poor (D^+ level) though the number of individuals were relatively high; health of Spe.-y is very good (B^+ level) though the number of individual were relatively low; and the health or quality of Spe.-z is fair (C^+ level).

Similarly, if one wishes to assess the average quality or health of a stand as a whole, the Jai-Sun value of it can be determined as below :

$$\text{Jai-Sun value of stand} = \frac{\Sigma(b_x + b_y + b_z)}{T_i(x + y + z)}$$

$$= \frac{(0.3042 + 0.2668 + 0.2016)}{(39 + 4 + 7)}$$

$$= \frac{0.7726}{50}$$

$$= 0.0154$$

This value indicates that the average quality or health of the stand with species x, y and z was satisfactory (C level).

Ad finem, it can be concluded that the calculations made through 'Jai-Sun Model' for determining the productive quality or health level of a species or of a stand can simply be derived from the contents of the data already pooled during the phytosociological studies just for analysing density, frequency, abundance etc., rather than going back and repeating the sample in order to obtain additional information.

Basal area or the thickness of a species has a great bearing on productiviy. A tentative budget of productivity of a forest can be made through 'Jai-Sun Model' for its management purposes. Such a programme can be launched not only at divisional level but at the State and the National level as well for understanding and assessing the health of Indian forests and their component species.

The author trusts that 'Jai-Sun Model' of quality determination, will go a long way to help arrive at an authentic decision in the shortest possible method and time.

3.3(c) B I O L O G I C A L S P E C T R U M

IN addition to phytosociological study, biological spectrums of all the five sites were prepared. All other

species of plants, which however, did not occured in quadrats, though present in the area, were also included in the floristic list for preparing the biological spectrum.

The concept of life-forms in the study of vegetation was proposed for the first time by Humboldt in 1806[162], who suggested groupings of vegetational types on the physiognomic basis. Several later workers emphasized the dependence of life-forms on climate and assessed the role of species in vegetation, with special reference to duration of protection to the perennating organs and mode of propagation[69, 106, 340, 481]. However, Raunkiaer's system[340] is the most widely accepted one and has been universally followed.

In the present study, attempts have been made to classify vegetation on the basis of life-forms which are the vegetational grouping of plants resulting from the interaction of all the life-processes, including those affecting the environment within the plant's life time.

Raunkiaer's life-form scheme recognised a number of categories into which plants were grouped, regardless of their taxonomic status, based on the "amount and kind of protection afforded to the buds and shoot apices". These are ut infra :

PHANEROPHYTES : These are trees, shrubs and or climbers in which the growing buds are located on the upright shoot much above the ground surface.

CHAMAEPHYTES : Perennating buds or shoot apices borne very close to the ground.

HEMICRYPTOPHYTES : Perennating buds at ground level, all above ground parts dying back at the onset of unfavourable conditions.

GEOPHYTES : Perennating buds below ground level or submerged in water.

THEROPHYTES : Annual species which complete a life cycle from seed to seed during favourable season of the year.

In addition to assigning the component species to life-form, other qualitative analysis were also carried out by ascribing them to growth and migrule forms[284] and sociability classes[285], etc.

3.3(d) I D E N T I F I C A T I O N S

PLANTS encountered during the entire study were initially identified by the local names or by attributing

them a number. Every time a new species met, was confiscated, dried and preserved in a reference collection. This reference collection was used to varify any questionable identification provided by woodsmen or some villager or forester. Generally their recognitions were accurate, though several species were some times lumped together under one designation. By constantly collecting the specimen and comparing it with the reference collection, it was rather possible to uncover inconsistencies and make distinctions between similar species.

Finally, the species were identified by comparing it with the local herbarium at Indian Grasslands and Fodder Research Institute, Jhansi and also from the available floras and the illustrations.

3.4 O B S E R V A T I O N S

FOR describing the vegetation of the five forest blocks, the plant species were assessed quantitatively and qualitatively.

3.4(a) P H Y T O S O C I O L O G Y

QUANTITATIVE appraisements for I.V.I., A/P ratio, percent density and percent basal area of various species of trees and other ground flora, as recorded in each of the five different blocks, are provided in Tables 3.2(a), 3.2(b), 3.2(c) 3.3, 3.4(a), 3.4(b), and 3.4(c).

3.4(a)-1 T R E E C O M M U N I T Y

Table - 3.2(a) serves to make know that in all 59 tree species were met during phytosociological study. Maximum 51 tree species occurred in the quadrats distributed in Chandpura forest (S-II), whereas, minimum 10 species made their appearance in Amravari forest (S-IV). Other blocks contributed 25, 21 and 46 species of trees in Bangawa (S-I), Laxmanpura (S-III) and Mayakhera (S-V) forests respectively.

Six tree species were altogether common in each of the forests studied. These were : Acacia catechu, Acacia nilotica, Anogeissus pendula, Bauhinia racemosa, Butea monosperma and Holoptelia integrifolia.

On the other hand Mallotus phillipinensis was exclusively present in S-I. In rest of the four blocks such endemic* cases were recorded with Ailanthus excelsa, Emblica officinalis, Ficus hispida, Ficus infectoria, Helicteres isora, Mimusops hexandra, Pithecellobium dulce and Prosopis spicigera - all of which were perceived only in S-II. Anogeissus sericea, Boswellia serrata, Feronia limonia, Grewia asiatica and Pterocarpus marsupium were endemic to S-V. However, none of the tree species was exclusively present in S-III and S-IV forest blocks.

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* Term 'endemic' is used throughout in this presents in very restricted sense, i.e., only in relation to the five sites surveyed.

TABLE - 3.2.(a) IMPORTANCE VALUE INDEX AND A/F RATIO OF THE TREE SPECIES ASSESSED DURING THEIR PHYTOSOCIOLOGICAL STUDIES IN FIVE DIFFERENT FOREST BLOCKS NEAR JHANSI.

NAME OF THE SPECIES	IMPORTANCE VALUE INDEX					A/F - RATIO				
	S - I	S - II	S - III	S - IV	S - V	S - I	S - II	S - III	S - IV	S - V
Acacia catechu	25.00	16.64	20.57	21.76	8.90	0.023	0.018	0.029	0.028	0.017
Acacia leucophloea	6.03	2.34	5.98	-	2.80	0.013	0.010	0.020	-	0.020
Acacia nilotica	15.93	7.54	14.56	13.06	9.91	0.009	0.009	0.020	0.017	0.009
Aegle marmelos	-	1.72	-	-	1.65	-	0.011	-	-	0.017
Ailanthus excelsa	-	0.93	-	-	-	-	0.007	-	-	-
Alangium lamarckii	1.30	1.35	-	-	1.26	0.017	0.009	-	-	0.007
Albizzia lebbek	1.59	1.17	1.92	-	2.31	0.040	0.012	0.042	-	0.020
Albizzia odoratissima	1.34	1.24	1.32	-	0.90	0.025	0.008	0.018	-	0.012
Albizzia procera	2.48	1.75	3.36	-	3.58	0.037	0.011	0.030	-	0.015
Anogeissus latifolia	-	3.46	-	-	12.01	-	0.030	-	-	0.017
Anogeissus pendula	131.89	111.23	123.70	167.19	125.55	0.112	0.202	0.135	0.125	0.173
Anogeissus sericea	-	-	-	-	2.60	-	-	-	-	0.031
Anona squamosa	-	0.84	-	-	0.91	-	0.002	-	-	0.005
Azadirachta indica	1.95	0.73	-	5.86	1.04	0.027	0.018	-	0.030	0.023
Balanites aegyptiaca	-	3.45	3.17	-	1.45	-	0.006	0.024	-	0.012
Bassia latifolia	1.70	1.73	-	4.37	2.33	0.046	0.011	-	0.025	0.025
Bauhinia racemosa	7.16	9.19	12.33	18.29	4.87	0.003	0.005	0.006	0.003	0.010
Boswellia serrata	-	-	-	-	4.98	-	-	-	-	0.034

(Continue

(Continued) (ii)

Bridelia retusa	-	2.73	-	-	2.47	-	0.011	-	-	0.026
Butea monosperma	43.38	23.13	28.76	45.76	18.46	0.062	0.037	0.055	0.060	0.031
Cassia fistula	1.78	0.95	-	-	1.33	0.018	0.009	-	-	0.011
Cordia myxa	-	1.63	-	-	2.14	-	0.010	-	-	0.043
Diospyros melanoxylon	-	5.21	-	-	6.98	-	0.015	-	-	0.014
Emblica officinalis	-	0.98	-	-	-	-	0.011	-	-	-
Feronia limonia	-	-	-	-	1.06	-	-	-	-	0.016
Ficus benghalensis	-	2.54	-	-	4.31	-	0.104	-	-	0.108
Ficus hispida	-	0.40	-	-	-	-	0.023	-	-	-
Ficus infectoria	-	1.02	-	-	-	-	0.134	-	-	-
Ficus religiosa	-	4.07	-	-	6.56	-	0.097	-	-	0.138
Garuga pinnata	-	2.13	-	-	1.62	-	0.017	-	-	0.016
Grewia asiatica	-	-	-	-	1.53	-	-	-	-	0.021
Helicteres isora	-	2.64	-	-	-	-	0.010	-	-	-
Holoptelea integrifolia	4.63	8.72	10.99	10.38	6.69	0.052	0.026	0.050	0.028	0.043
Lagerstroemia parviflora	-	4.35	-	-	5.27	-	0.021	-	-	0.019
Lannea coromandelica	-	3.57	17.07	-	6.43	-	0.025	0.038	-	0.016
Mallotus phillipinensis	0.60	-	-	-	-	0.021	-	-	-	-
Millingtonia hortensis	-	1.59	1.26	-	1.94	-	0.009	0.014	-	0.014
Mimosa rubicaulis	-	1.62	-	-	1.42	-	0.007	-	-	0.006
Minusops hexendra	-	2.79	-	-	-	-	0.017	-	-	-
Mitragyna parviflora	-	-	5.26	-	4.05	-	-	0.017	-	0.013

(Continue)..

(Continued) (iii)

Nyctanthes arbor-tristis	3.23	4.29	4.71	-	3.27	0.003	0.008	0.004	-	0.004
Ougenia dalbergioides	-	3.15	-	-	2.55	-	0.009	-	-	0.015
Pithecellobium dulce	-	1.35	-	-	-	-	0.016	-	-	-
Prosopis spicigera	-	1.00	-	-	-	-	0.003	-	-	-
Pterocarpus marsupium	-	-	-	-	1.73	-	-	-	-	0.021
Randia dumetorum	-	3.11	3.14	-	-	-	0.011	0.015	-	-
Salmalia malabarica	0.93	2.19	1.46	-	1.53	0.058	0.010	0.032	-	0.021
Sapindus laurifolius	-	2.45	-	-	1.64	-	0.012	-	-	0.022
Sterculia urens	-	5.58	6.75	-	4.82	-	0.016	0.051	-	0.024
Tamarindus indica	0.62	0.80	-	1.92	-	0.003	0.024	-	0.016	-
Tectona grandis	3.57	4.48	-	-	3.04	0.030	0.029	-	-	0.014
Terminalia arjuna	-	1.01	-	-	1.30	-	0.013	-	-	0.010
Terminalia belerica	1.30	1.15	-	-	-	0.023	0.015	-	-	-
Terminalia tomentosa	0.62	-	-	-	0.51	0.023	-	-	-	0.021
Wrightia tinctoria	2.80	5.52	6.33	-	5.59	0.024	0.010	0.033	-	0.017
Wrightia tomentosa	-	5.56	-	-	0.89	-	0.008	-	-	0.012
Zizyphus mauritiana	20.76	10.52	14.27	-	8.55	0.015	0.005	0.011	-	0.006
Zizyphus nummularia	5.33	2.85	-	11.41	-	0.002	0.004	-	0.002	-
Zizyphus xylopyrus	14.08	6.15	13.09	-	5.27	0.014	0.004	0.006	-	0.007
TOTAL	300.00	300.00	300.00	300.00	300.00	0.039	0.034	0.046	0.057	0.041

LEGENDS : S - I = Dangawa, S - II = Chandpura, S - III = Laxmanpura, S - IV = Simravari, S - V = Nayakhera

Percentage distribution of the species in frequency class A was relatively much high in all the five forest blocks because of the presence of numerous sporadic species, whereas, frequency classes D and E were relatively very low in each of the five sites. This indicates a heterogeneous nature of the tree community present in the forests (Table - 3.2b).

The overall notation of frequency classes in each of the five sites and of Raunkiaer's normal[339] can be written as :

S-I	:	A	>	B	>	C	>	D	= E
S-II	:	A	>	B	=	C	>	D	= E
S-III	:	A	>	B	=	C	>	D	< E
S-IV	:	A	>	B	>	C	>	D	< E
S-V	:	A	>	B	>	C	>	D	= E
R.'s Normal	:	A	>	B	>	C	$\gtrless$	D	< E

Raunkiaer's J - shaped distribution curve and the similar relationships between frequencies and the percentages of species falling within each of the frequency classes in five forest blocks studied are provided in Fig. - 3

Regarding density, Bangawa block was most thickly populated forest stand with 4052 trees/ha. This was followed by Chandpura, Lamanpura, Mayakhera and Simravari forests

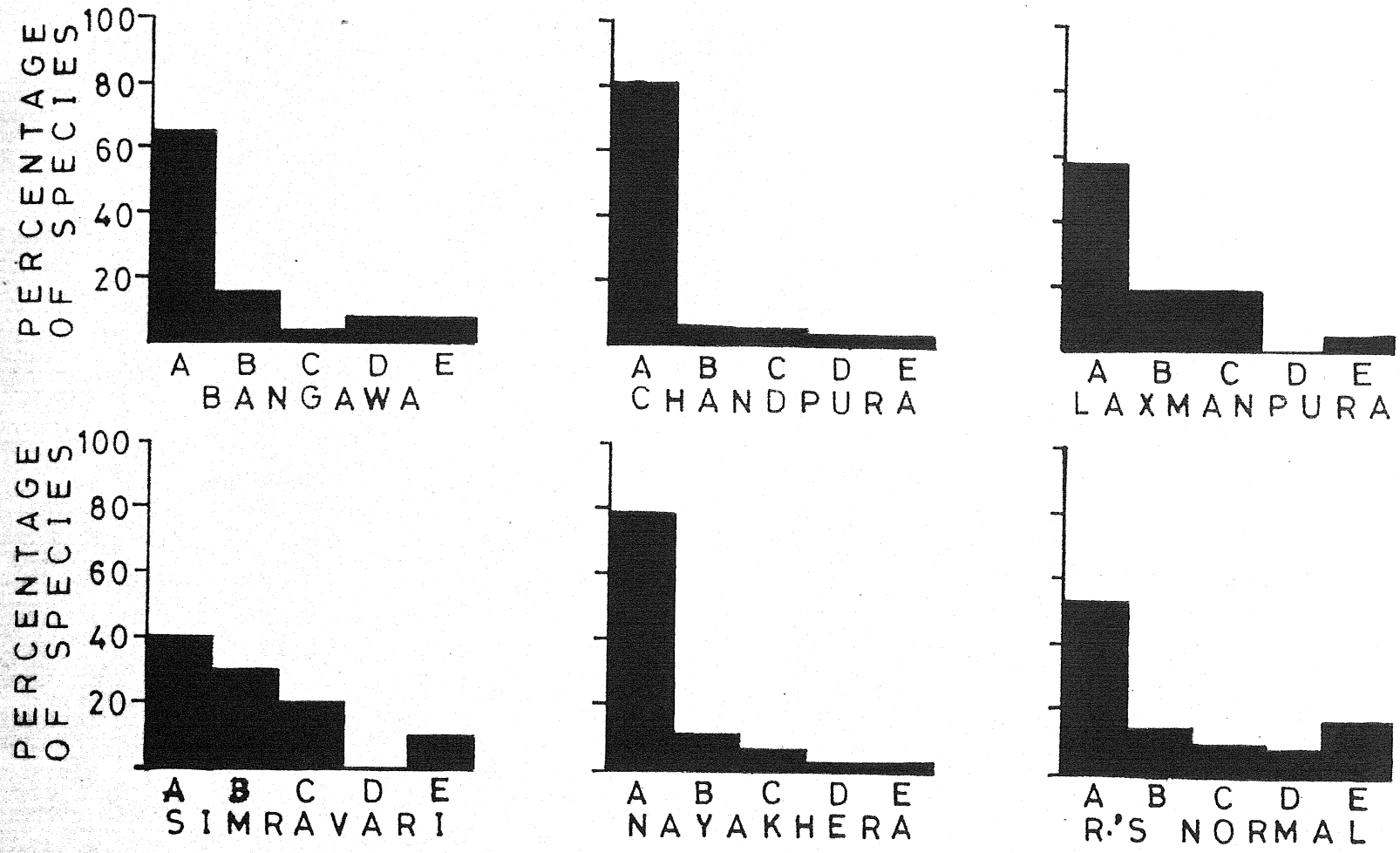


FIG. 3-1 THE RELATIONSHIP BETWEEN FREQUENCY CLASS AND THE PERCENTAGE OF WOODY SPECIES FALLING WITHIN EACH OF THE CLASSES IN FIVE DIFFERENT FOREST BLOCKS AND THE RAUNKIAER'S WORLD NORMAL.

TABLE - 3.2.(b) PERCENTAGE DISTRIBUTION OF FREQUENCY CLASSES OF THE TREE SPECIES PRESENT IN FIVE DIFFERENT FOREST BLOCKS.

FREQUENCY CLASS	PERCENT DISTRIBUTION				
	S - I	S - II	S - III	S - IV	S - V
A	64.00	80.40	57.14	40.00	78.26
B	16.00	5.88	19.05	30.00	10.88
C	4.00	5.88	19.05	20.00	6.52
D	8.00	3.92	-	-	2.17
E	8.00	3.92	4.76	10.00	2.17
TOTAL SPECIES :	25	51	21	10	46

LEGENDS : S - I : Bangawa, S - II : Chandpura,
S - III : Laxmanpura, S - IV : Jimravari, S - V : Nayakhera

TABLE - 3.2.(e) INDEX OF SIMILARITY AND DISSIMILARITY BETWEEN FIVE COMMUNITIES OF TREE SPECIES.

SITES	INDEX OF SIMILARITY AND DISSIMILARITY			
S - II	0.5750			
	(0.4250)			
S - III	0.6522	0.5263		
	(0.3478)	(0.4737)		
S - IV	0.5714	0.3077	0.3871	
	(0.4286)	(0.6923)	(0.6129)	
S - V	0.5833	0.7647	0.5882	0.2807
	(0.4167)	(0.2353)	(0.4118)	(0.7193)

SITES	S - I	S - II	S - III	S - IV

NOTE : Values in parenthesis are of dissimilarity otherwise of similarity.

LEGENDS : S - I : Bangawa S - II : Chandpura S - III : Laxmanpura S - IV : Simravari S - V : Kayakhera

with 2488 trees/ha, 2016 trees/ha, 1932 trees/ha and 1332 trees/ha respectively. Contributions made by Anogeissus pendul in each of these forests were relatively the highest with densities of 1994, 1166, 1022, 892 and 1096 trees/ha in S-I, S-II, S-III, S-IV and S-V respectively. Thus it was 49.21, 46.36, 50.69, 66.97 and 56.21 percent respectively of the tot density in each of the forest blocks. (Table - 3.3).

Further, A.pendula was also the most dominant tre present in each of the five sites studied with its Importance Value Index of the following ranges : 131.89, 11.23, 123.70, 167.19 and 125.55 in Bangawa, Chandpura, Laxmanpura, Simravari and Mayakhera forests respecively (Table - 3.2a).

Interestingly enough, Butea monosperma was the common co-dominant tree present in each of the said five block with 43.38, 23.13, 28.76, 45.76 and 18.46 I.V.Is., respectivel Phytographs of the three most dominant tree species in each of the five forest sites are prepared in Fig. 3.2

The distribution patterns on the basis of A/F ratios of the species suggest that A.pendula was the only tree species with contagious distribution in each of the five forest blocks. One may not get surprised by observing that A.pendula has obtained maximum A/F ratios in each sites as inscribed in Table 3.2(a). A/F ratios of 'Kardhai' were :

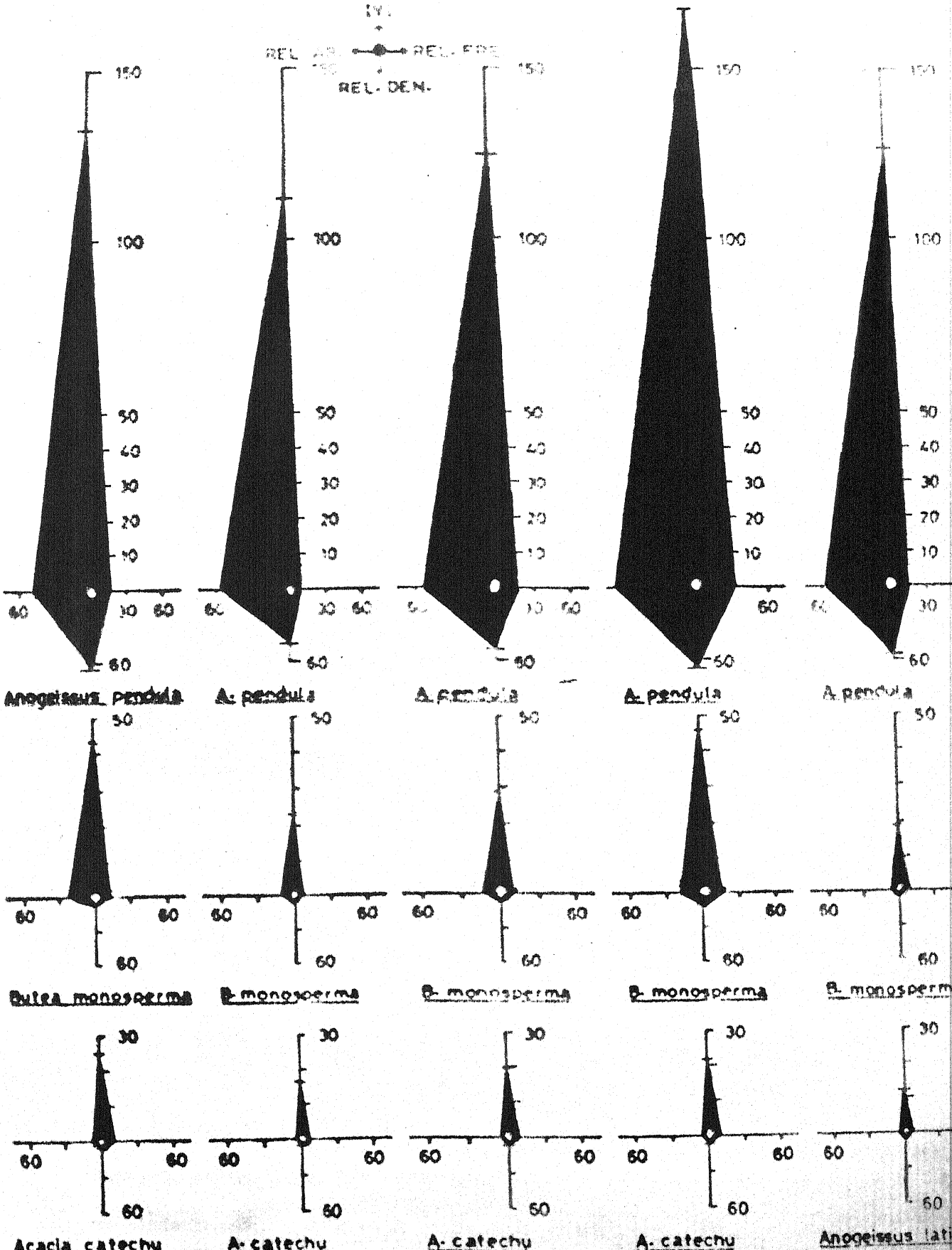


FIG-32 PHYTOGRAPHS OF THE THREE MOST DOMINANT TREE SPECIES IN THE COMMUNITY STRUCTURE OF FIVE DIFFERENT FOREST BLOCKS.

TABLE - 3.3 DENSITY PER HECTARE AND THE JAI - SUN VALUES OF THE TREE SPECIES ASSESSED DURING THEIR PHYTOSOCIOLOGICAL STUDIES IN FIVE DIFFERENT FOREST BLOCKS NEAR JHANSI.

NAME OF THE SPECIES	D E N S I T Y/ ha					J A I - S U N V A L U E S				
	S - I	S - II	S - III	S - IV	S - V	S - I	S - II	S - III	S - IV	S - V
Acacia catechu	178	128	146	90	42	0.018	0.023	0.018	0.020	0.028
Acacia leucophloea	28	116	34	-	16	0.021	0.017	0.019	-	0.025
Acacia nilotica	102	58	122	54	54	0.011	0.014	0.010	0.014	0.014
Aegle marmelos	-	12	-	-	10	-	0.018	-	-	0.021
Ailanthus excelsa	-	6	-	-	-	-	0.015	-	-	-
Alangium lamarckii	10	10	-	-	6	0.013	0.014	-	-	0.015
Albizzia lebbek	6	10	10	-	14	0.053	0.015	0.034	-	0.023
Albizzia odoratissima	6	8	6	-	4	0.034	0.015	0.023	-	0.025
Albizzia procera	14	12	18	-	20	0.032	0.019	0.027	-	0.021
Anogeissus latifolia	-	24	-	-	58	-	0.035	-	-	0.028
Anogeissus pendula	1994	1166	1022	892	1086	0.011	0.035	0.026	0.028	0.032
Anogeissus sericea	-	-	-	-	14	-	-	-	-	0.035
Anona squamosa	-	6	-	-	6	-	0.004	-	-	0.006
Azadirachta indica	6	4	-	14	4	0.054	0.035	-	0.043	0.045
Balanites aegyptiaca	-	26	18	-	8	-	0.010	0.022	-	0.018
Bassia latifolia	6	12	-	10	12	0.062	0.015	-	0.040	0.033
Bauhinia racemosa	48	74	78	58	36	0.003	0.008	0.007	0.004	0.008
Boswellia serrata	-	-	-	-	20	-	-	-	-	0.055
Bridelia retusa	-	18	-	-	14	-	0.020	-	-	0.030

(Continue)..

(Continued)

Butea monosperma	204	154	118	146	76	0.050	0.042	0.053	0.044	0.050
Cassia fistula	8	6	-	-	6	0.027	0.017	-	-	0.023
Cordia myxa	-	10	-	-	10	-	0.021	-	-	0.051
Diospyros melanoxylon	-	36	-	-	38	-	0.023	-	-	0.021
Emblica officinalis	-	6	-	-	-	-	0.022	-	-	-
Feronia limonia	-	-	-	-	6	-	-	-	-	0.022
Ficus benghalensis	-	6	-	-	8	-	0.207	-	-	0.217
Ficus hispida	-	2	-	-	-	-	0.045	-	-	-
Ficus infectoria	-	2	-	-	-	-	0.267	-	-	-
Ficus religiosa	-	10	-	-	14	-	0.194	-	-	0.197
Garuga pinnata	-	18	-	-	10	-	0.019	-	-	0.019
Grewia asiatica	-	-	-	-	6	-	-	-	-	0.043
Helicteres isora	-	30	-	-	-	-	0.008	-	-	-
Holoptelea integrifolia	18	44	50	26	34	0.058	0.049	0.044	0.038	0.046
Lagerstroemia parviflora	-	40	-	-	26	-	0.019	-	-	0.030
Lannea coromandelica	-	76	86	-	36	-	0.022	0.033	-	0.026
Mallotus phillipinensis	2	-	-	-	-	0.041	-	-	-	-
Millingtonia hortensis	-	10	6	-	10	-	0.018	0.018	-	0.022
Mimosa rubicaulis	-	18	-	-	10	-	0.006	-	-	0.007
Mimusops hexendra	-	20	-	-	-	-	0.024	-	-	-
Mitragyna parviflora	-	-	34	-	24	-	-	0.014	-	0.017
Nyctanthes arbor-tristis	18	50	22	--	18	0.005	0.006	0.006	-	0.007
Ougenia dalbergioides	-	26	-	-	14	-	0.012	-	-	0.021
Pithecellobium dulce	-	12	-	-	-	-	0.026	-	-	-

(Continue)..

(Continued)

Prosopis spicigera	-	10	-	-	-	-	0.003	-	-	-
Pterocarpus marsupium	-	-	-	-	10	-	-	-	-	0.026
Randia dumetorum	-	28	14	-	-	-	0.013	0.021	-	-
Salmalia malabarica	2	6	4	-	6	0.116	0.051	0.065	-	0.043
Sapindus laurifolius	-	16	-	-	8	-	0.022	-	-	0.030
Sterculia urens	-	24	26	-	20	-	0.028	0.055	-	0.043
Tamarindus indica	2	4	-	4	-	0.046	0.047	-	0.032	-
Tectona grandis	34	52	-	-	24	0.014	0.015	-	-	0.012
Terminalia arjuna	-	6	-	-	6	-	0.025	-	-	0.020
Terminalia belerica	6	8	-	-	-	0.031	0.023	-	-	-
Terminalia tomentosa	2	-	-	-	2	0.045	-	-	-	0.043
Wrightia tinctoria	18	46	38	-	28	0.021	0.014	0.024	-	0.027
Wrightia tomentosa	-	46	-	-	4	-	0.011	-	-	0.023
Zizyphus mauritiana	166	96	94	-	42	0.012	0.007	0.009	-	0.011
Zizyphus nummularia	30	30	-	38	-	0.003	0.004	-	0.003	-
Zizyphus xylopyrus	142	50	70	-	36	0.008	0.006	0.008	-	0.008
TOTAL	3050	2588	2008	1332	1956	0.015	0.028	0.025	0.027	0.031

LEGENDS : S - I = Bangawa, S - II = Chandpura, S - III = Laxmanpura, S - IV = Sinravari,
S - V = Nayakhera

(Continued)

Prosopis spicigera	-	10	-	-	-	-	0.003	-	-	-
Pterocarpus marsupium	-	-	-	-	10	-	-	-	-	0.026
Randia dumetorum	-	28	14	-	-	-	0.013	0.021	-	-
Salmalia malabarica	2	6	4	-	6	0.116	0.051	0.065	-	0.043
Sapindus laurifolius	-	16	-	-	8	-	0.022	-	-	0.030
Sterculia urens	-	24	26	-	20	-	0.028	0.055	-	0.043
Tamarindus indica	2	4	-	4	-	0.046	0.047	-	0.032	-
Tectona grandis	34	52	-	-	24	0.014	0.015	-	-	0.012
Terminalia arjuna	-	6	-	-	6	-	0.025	-	-	0.020
Terminalia belerica	6	8	-	-	-	0.031	0.023	-	-	-
Terminalia tomentosa	2	-	-	-	2	0.045	-	-	-	0.043
Wrightia tinctoria	18	46	38	-	28	0.021	0.014	0.024	-	0.027
Wrightia tomentosa	-	46	-	-	4	-	0.011	-	-	0.023
Zizyphus mauritiana	166	96	94	-	42	0.012	0.007	0.009	-	0.011
Zizyphus nummularia	30	30	-	38	-	0.003	0.004	-	0.003	-
Zizyphus xylopyrus	142	50	70	-	36	0.008	0.006	0.008	-	0.008
TOTAL	3050	2588	2008	1332	1956	0.015	0.028	0.025	0.027	0.031

LEGENDS : S - I = Bangawa, S - II = Chandpura, S - III = Laxmanpura, S - IV = Simravari,
S - V = Nayakhera

0.112, 0.202, 0.135, 0.125 and 0.173 in Bangawa, Chandpura, Laxmanpura, Simravari and Nayakhera forests respectively.

As rests A.pendula, three more species of trees were also found contagious in distribution in the sites of their occurrence. These were Ficus benghalensis, and F.religiosa both commonly in S-II and S-V blocks. A/F ratios of these two species were 0.104 and 0.197 in Chandpura and 0.108 and 0.138 in Nayakhera forests respectively. However, the third species i.e., Ficus infectoria was the only endemic species occurring in Chandpura forest with A/F ratios 0.134

Four other species of trees were also contagious in their distribution but in one or the other sites besides being irregularly or randomly distributed in rest of the sites. These were : Butea monosperma (S-I, S-III and S-IV); Holoptelia integrifolia and Salmalia malabarica (both in S-I); and Sterculia urens (S-III).

Interestingly enough, except A.pendula, A.serissa, Boswellia serrata, Butea monosperma, Ficus benghalensis, Ficus infectoria, Ficus religiosa and Holoptelia integrifolia rest all the 51 tree species (out of the total 59) were irregular in their distributions in one or more sites. More accurately, 38 tree species were uniformly irregular in their

distributions in all the forest blocks in which they made their appearances. Two endemic tree species A.serricea and Boswellia serrata (both occurring only in S-V) with A/F ratios 0.031 and 0.034 respectively, were randomly distributed in Mayakhera forest.

Eleven more species were also randomly apportionmented in some sites besides their irregular allocations in other sites. These were : Acacia catechu (S-III and S-IV), Albizia lebbek and A.procera (both in S-I and S-III). Anogeissus latifolia (S-II), Azadirachta indica (S-I and S-IV). Bassia latifolia (S-I), Bridelia retusa and Cordia myxa (both in S-V), Lannea coromandelica (S-III), Tectona grandis (S-I and S-II) and Wrightia tinctoria (S-III).

Salmalia malabarica was the only tree species exhibiting all the three patterns of distribution. It was diffused irregularly in Chandpura (0.010) and Mayakhera (0.021), randomly in Laxmanpura (0.032) and contagiously in Bangawa (0.058).

Site-wise total number of species can be grouped on the basis of their spreadings ut infra :

PATTERN OF DISTRIBUTION	NUMBER OF SPECIES IN S-I	S-II	S-III	S-IV	S-V
(1). Irregular	16	43	11	05	37
(2). Random	05	04	07	03	06
(3). Contagious	04	04	03	02	03

3.4(a)-ii F L O O R F L O R A

A perusal of the Table 3.4a indicates that in all 176 species of ground vegetation made their appearance in the quadrats during phytosociological study. Site-wise representation of the species were : 51, 89, 135, 32 and 64 in Bangawa, Chandpura, Laxmanpura, Simravari and Nayakhera respectively. The following 20 species of ground layer occurred in each of the five forest blocks : Achyranthes aspera, Cassia pumila, Cassia tora, Commelina benghalensis, Corchorus aestuans, Cynodon dactylon, Digitaria adscendens, Eletraria acaulis, Eragrostis ciliaris, Euphorbia hirta, Ipomoea pes-tigridis, Murdannia nudiflora, Peristrophe bicalyculata, Aungia pectinata, Aungia repens, Sida cordata, Sida cordifolia, Tridax procumbens, Vernonia cinerea and Zornia gibbosa.

Number of species making their semblance in only one of the five sites were 6, 16, 62, nil and 6 in Bangawa, Chandpura, Laxmanpura, Simravari and Nayakhera forests respectively. These so called endemic species can be enumerated ut infra :

S-I : Adiantum philippense, Aniscchilus carnosus, Enicostema hyssopifolium, Eragrostis tremula, Molluga pentaphylla and Trianthema portulacastrum.

TABLE - 3.4.(a) IMPORTANCE VALUE INDEX, A/F RATIO AND DENSITY/m^2 OF THE HERBACEOUS SPECIES INCLUDING GRASS AAS ASSESSED DURING THEIR PHYTOSOCIOLOGICAL STUDIES IN FIVE DIFFERENT FOREST BLOCKS NEAR MHANSI.

NAME OF THE SPECIES	IMPORTANCE VALUE INDEX AND DENSITY/ ha.					A/F - RATIO OF THE SPECIES				
	S - I	S - II	S - III	S - IV	S - V	S - I	S - II	S - III	S - IV	S - V
Abelmoschus crinitus	-	-	0.65 (0.76)	-	-	-	-	0.079	-	-
Abelmoschus manihot	-	0.44 (0.02)	-	-	-	-	0.500	-	-	-
Abutilon indicum	-	0.75 (0.06)	-	-	0.74	-	0.375	-	-	0.375
Acalypha ciliata	-	-	0.36 (0.06)	-	-	-	-	0.375	-	-
Acalypha indica	-	-	0.97 (0.30)	-	-	-	-	0.061	-	-
Acanthospermum hispidum	-	1.17 (0.14)	1.01 (0.42)	-	-	-	0.140	0.291	-	-
Achyranthes aspera	1.43 (0.14)	1.25 (0.16)	1.33 (0.66)	2.86 (0.14)	1.17 (0.14)	0.218	0.160	0.136	0.219	0.388
Adhatoda vasica	-	-	0.51 (0.06)	-	-	-	-	1.500	-	-
Adiantum caudatum	-	3.21 (0.66)	-	-	1.69 (0.22)	-	0.660	-	-	0.610
Adiantum philippense	3.21 (0.52)	-	-	-	-	0.520	-	-	-	-
Ageratum conyzoides	-	-	1.06 (0.46)	-	0.92 (0.08)	-	-	0.179	-	0.500

(Continued)

Alternanthera sessilis	3.25 (0.54)	3.21 (0.78)	0.73 (0.76)	-	3.87 (1.34)	0.111	0.135	0.327	-	0.043
Alysicarpus bupleurifolius	-	-	1.11 (0.50)	-	-	-	-	0.255	-	-
Alysicarpus hamosus	9.48 (3.18)	-	0.57 (0.14)	-	-	0.150	-	0.388	-	-
Alysicarpus longifolius	-	-	-	-	2.10 (0.46)	-	-	-	-	0.234
Alysicarpus monilifer	6.28 (1.50)	-	7.29 (9.06)	-	2.32 (0.76)	0.085	-	0.106	-	0.234
Alysicarpus rugosus	2.56 (0.38)	-	-	-	2.75 (0.74)	0.148	-	-	-	0.109
Alysicarpus vaginalis	3.11 (0.56)	2.62 (0.54)	2.53 (1.74)	12.39 (1.16)	-	0.360	0.111	0.536	0.592	-
Amischophacelus axillaris	1.48 (0.14)	-	0.80 (0.28)	-	-	0.140	-	0.194	-	-
Andrographis echioides	-	1.37 (0.18)	0.95 (0.38)	-	-	-	0.125	0.193	-	-
Anisochilus carnosus	1.33 (0.10)	-	-	-	-	0.625	-	-	-	-
Anisomeles indica	-	-	0.36 (0.06)	-	-	-	-	0.375	-	-
Apluda mutica	2.03 (0.26)	-	2.93 (2.38)	3.95 (0.24)	-	0.180	-	0.122	0.240	-
Argemone mexicana	-	-	1.49 (0.78)	-	-	-	-	0.397	-	-
Aristida adscensionis	1.72 (0.14)	-	10.34 (15.26)	3.61 (0.12)	9.86	0.875	-	0.226	0.750	0.192

(Continue)..

(Continued)

Azanza lampus	-	-	1.96 (1.64)	-	-	-	-	0.375	-	-
Barleria cristata	-	-	0.36 (0.06)	-	-	-	-	0.375	-	-
Barleria strigosa	-	-	1.46 (0.06)	-	-	-	-	0.375	-	-
Bidens bipinnata	-	1.55 (0.22)	1.21 (0.54)	-	-	-	0.112	0.111	-	-
Biophytum sensitivum	1.13 (0.08)	1.67 (0.22)	-	-	2.32 (0.56)	0.500	0.610	-	-	0.172
Blainvillea acmela	-	0.92 (0.08)	1.27 (0.62)	-	-	-	0.500	0.315	-	-
Blumea lacera	-	2.05 (0.38)	2.40 (2.90)	-	2.89 (0.86)	-	0.263	0.495	-	0.126
Boerhavia diffusa	-	0.96 (0.10)	0.67 (0.20)	-	0.92 (0.10)	-	0.276	0.312	-	0.276
Boerhavia verticillata	-	-	0.51 (0.10)	-	-	-	-	0.625	-	-
Borreria brachystema	6.14 (1.66)	3.05 (0.74)	1.41 (0.40)	-	1.08 (0.14)	0.184	0.228	0.516	-	0.218
Bothriochloa pertusa	-	-	1.11 (0.50)	-	-	-	-	0.255	-	-
Brachiaria burgii	-	3.06 (0.62)	-	-	-	-	0.620	-	-	-
Brachiaria reptans	12.43 (2.54)	3.52 (0.86)	-	-	12.10 (7.54)	0.254	0.438	-	-	0.196
Cassia absus	0.93 (0.06)	0.75 (0.06)	1.03 (0.42)	1.48 (0.04)	1.36 (0.24)	0.375	0.375	0.129	0.250	0.750
Cassia pumila	1.30 (0.06)	3.02 (0.72)	14.03 (22.78)	-	1.74 (0.34)	1.500	0.281	0.227	-	0.172

(Continue)..

(Continued)

Cassia tora	1.03 (0.10)	2.17 (0.42)	3.06 (2.26)	2.01 (0.06)	8.93 (4.46)	0.415	0.214	0.071	0.375	0.063
Cayratia trifolia	-	-	0.68 (0.18)	-	-	-	-	0.500	-	-
Celosia argentea	-	1.42 (0.14)	-	-	-	-	0.875	-	-	-
Chloris virgata	-	-	0.86 (0.30)	-	-	-	-	0.116	-	-
Cissampelos pariera	-	-	0.79 (0.22)	-	-	-	-	0.610	-	-
Cleome viscosa	-	1.06 (0.12)	0.64 (0.18)	-	-	-	0.137	0.125	-	-
Cocculus villosus	-	-	1.52 (1.21)	-	-	-	-	0.340	-	-
Commelina benghalensis	2.44 (0.28)	9.10 (3.78)	2.08 (1.36)	8.32 (0.82)	2.13 (0.42)	0.776	0.129	0.117	0.253	0.061
Commelina paludosa	-	-	1.85 (1.48)	-	-	-	-	0.174	-	-
Convolvulus arvensis	-	1.08 (0.10)	-	-	-	-	0.625	-	-	-
Corchorus aestuans	21.66 (10.34)	5.26 (1.58)	12.66 (19.94)	6.00 (0.54)	10.85 (6.26)	0.153	0.089	0.199	0.094	0.084
Corchorus fascicularis	-	1.64 (0.26)	-	-	-	-	0.180	-	-	-
Corchorus trilocularis	-	1.17 (0.14)	-	-	-	-	0.140	-	-	-
Corongpus didymus	-	-	1.11 (0.34)	-	-	-	-	0.943	-	-
Crotalaria medicaginea	-	1.20 (0.14)	0.73 (0.22)	-	-	-	0.388	0.112	-	-

(Continue)..

Crotalaria prostrata	-	1.07 (0.06)	-	-	-	-	1.500	-	-	-
Cynodon dactylon	2.39 (0.34)	2.84 (0.64)	4.74 (4.98)	4.62 (0.26)	3.38 (1.06)	0.340	0.326	0.129	0.406	0.183
Cyperus alopecuroides	-	-	0.76 (0.24)	-	-	-	-	0.375	-	-
Cyperus corymbosus	-	1.42 (0.14)	1.45 (0.78)	6.15 (0.50)	1.92 (0.26)	-	0.875	0.304	0.255	0.721
Cyperus iria	-	-	1.14 (0.42)	-	-	-	-	0.656	-	-
Cyperus kyllingia	-	-	1.04 (0.50)	-	-	-	-	0.500	-	-
Cyperus niveus	-	1.55 (0.22)	1.06 (0.46)	7.38 (0.64)	1.38 (0.22)	-	0.112	0.179	0.036	0.220
Cyperus rotundus	-	-	1.27 (0.62)	-	-	-	-	0.315	-	-
Dactyloctenium aegyptium	2.31 (0.30)	5.02 (1.58)	-	-	9.04 (4.84)	0.468	0.136	-	-	0.093
Dactyloctenium aristatum	-	-	6.41 (7.90)	-	-	-	-	0.181	-	-
Dactyloctenium sindicum	-	3.08 (0.74)	-	5.48 (0.46)	-	-	0.288	-	0.142	-
Desmodium gangeticum	-	1.55 (0.20)	-	5.29 (0.42)	-	-	0.555	-	0.062	-
Desmodium neo-mexicana	1.81 (0.18)	1.15 (0.14)	1.14 (0.42)	-	-	0.091	0.218	0.656	-	-
Desmodium triflorum	-	-	-	-	1.58 (0.28)	-	-	-	-	0.109
Dichanthium annulatum	-	2.97 (0.82)	3.13 (2.70)	7.29 (0.62)	-	-	0.197	0.300	0.316	-
Digitaria adsenscionis	5.21 (1.14)	4.75 (1.46)	4.71 (5.04)	5.42 (0.36)	5.26 (2.18)	0.581	0.301	0.160	0.360	0.186

(Continue)..

(Continued)

Dipteracanthus beddomei	-	-	0.46 (0.10)	-	-	-	-	0.276	-	-
Echinochloa crus-galli	-	-	1.19 (0.52)	-	-	-	-	0.107	-	-
Eclipta prostrata	-	-	1.01 (0.42)	-	-	-	-	0.291	-	-
Elytraria acaulis	3.42 (0.42)	3.27 (0.78)	1.92 (1.06)	10.09 (1.22)	4.07 (1.34)	1.166	0.397	0.073	0.136	0.075
Emilia sonchifolia	2.02 (0.26)	-	-	-	-	0.260	-	-	-	-
Eragrostis bifaria	-	-	1.76 (1.06)	-	-	-	-	0.326	-	-
Eragrostis ciliaris	8.32 (1.46)	13.51 (6.38)	11.64 (17.86)	31.49 (6.14)	17.79 (12.76)	2.281	0.441	0.202	0.069	0.232
Eragrostis diarrhena	-	-	2.07 (1.20)	-	-	-	-	0.612	-	-
Eragrostis pilosa	-	9.21 (4.54)	3.71 (3.56)	-	14.95 (10.22)	-	0.953	0.201	-	0.151
Eragrostis poaeoides	-	-	0.79 (0.22)	-	-	-	-	0.610	-	-
Eragrostis tremula	18.54 (7.94)	-	-	-	-	0.549	-	-	-	-
Eremopogon foveolatus	-	-	1.80 (1.70)	-	-	-	-	0.120	-	-
Eriochloa procera	-	-	1.31 (1.18)	-	-	-	-	0.110	-	-
Euphorbia hirta	1.57 (0.16)	3.93 (1.02)	0.85 (0.26)	4.49 (0.28)	3.20 (0.96)	0.160	0.314	0.080	0.280	0.198
Euphorbia prostrata	-	1.25 (0.12)	-	-	1.54 (0.08)	-	0.750	-	-	0.260
Evolvulus alsinoides	2.84 (0.42)	2.41 (0.50)	1.43 (0.74)	-	1.50 (0.26)	0.105	0.255	0.160	-	0.180

(Continue)..

Gomphrena celosioides	-	-	0.51 (0.06)	-	-	-	-	1.500	-	-
Gomphrena globosa	-	-	0.79 (0.22)	-	-	-	-	0.610	-	-
Gynandropsis pentaphylla	-	-	1.65 (0.98)	-	-	-	-	0.202	-	-
Heliotropium strigosum	5.34 (1.22)	5.39 (1.74)	1.21 (0.58)	-	1.74	0.105	0.359	0.178	-	0.172
Heteropogon contortus	-	-	5.34 (6.08)	-	-	-	-	0.180	-	-
Hibiscus lobatus	-	0.84 (0.08)	0.50 (0.12)	-	-	-	0.221	0.187	-	-
Hybanthus enneaspermum	-	-	-	5.78 (0.50)	1.86 (0.38)	-	-	-	0.074	0.193
Indigofera cordifolia	2.09 (0.26)	-	2.51 (1.72)	4.32 (0.30)	-	0.132	-	0.530	0.062	-
Indigofera hirsuta	-	-	0.72 (0.22)	-	-	-	-	0.343	-	-
Indigofera linifolia	-	1.75 (0.18)	-	-	-	-	1.125	-	-	-
Indigofera oblongifolia	-	1.67 (0.22)	-	-	-	-	0.610	-	-	-
Ipomoea alba	-	-	-	-	0.74 (0.06)	-	-	-	-	0.375
Ipomoea arachnosperma	-	-	0.40 (0.14)	-	-	-	-	0.140	-	-
Ipomoea eriocarpa	-	1.80 (0.26)	-	-	-	-	0.080	-	-	-
Ipomoea pes-tigridia	1.06 (0.08)	2.68 (0.46)	1.97 (1.02)	5.94 (0.46)	1.07 (0.14)	0.221	0.058	0.055	0.040	0.140
Ipomoea sindica	-	1.33 (0.18)	0.80 (0.26)	-	-	-	0.180	0.406	-	-

(Continue)..

Ipecilema laxum	-	-	3.54 (3.30)	-	-	-	-	0.254	-	-
Lepidagathis incurva	0.93 (0.06)	0.75 (0.06)	-	-	-	0.375	0.375	-	-	-
Leucas aspera	-	-	1.01 (0.40)	-	-	-	-	0.123	-	-
Lindenbergia indica	-	0.75 (0.06)	0.36 (0.04)	-	-	-	0.375	1.000	-	-
Lindernia ciliata	12.52 (3.36)	9.50 (3.98)	1.21 (2.10)	-	27.26 (22.58)	0.058	0.118	0.069	-	0.225
Lindernia crustacea	-	-	0.95 (0.28)	-	7.03 (3.42)	-	-	0.776	-	0.161
Ludwigia octovalvis	-	2.32 (0.46)	-	-	-	-	0.141	-	-	-
Ludwigia perrenis	-	-	0.72 (0.22)	-	2.50 (0.64)	-	-	0.343	-	0.131
Malva parviflora	-	-	2.56 (2.41)	-	-	-	-	0.155	-	-
Malvastrum coromandelianum	-	0.75 (0.04)	2.10 (1.61)	-	2.05 (0.42)	-	1.000	0.090	-	0.291
Melanocenchris jacquemontii	-	-	2.43 (1.82)	-	-	-	-	0.157	-	-
Melochia corchorifolia	-	-	6.12 (7.42)	-	-	-	-	0.220	-	-
Merremia aegyptiaca	-	-	-	-	0.85 (0.04)	-	-	-	-	1.000
Mollugo pentaphylla	1.72 (0.14)	-	-	-	-	0.875	-	-	-	-
Mukia maderaspatana	-	-	0.43 (0.10)	-	-	-	-	0.276	-	-
Murdannia nudiflora	12.97 (4.10)	5.52 (1.54)	8.20 (10.90)	29.37 (5.64)	18.38 (13.54)	0.055	0.061	0.128	0.080	0.135

(Continue).

(Continued)

Murdannia spirata	-	2.71 (0.58)	4.61 (4.86)	-	-	-	0.119	0.143	-	-
Ocimum basilicum	-	-	0.89 (0.34)	-	-	-	-	0.172	-	-
Oldenlandia affinis	-	-	1.21 (0.54)	-	-	-	-	0.111	-	-
Oldenlandia corymbosa	6.57 (1.82)	2.99 (0.70)	2.28 (1.66)	-	16.27 (11.38)	0.157	0.144	0.245	-	0.207
Oplismenus burmanii	16.48 (6.96)	4.65 (1.42)	1.78 (0.42)	31.60 (6.24)	-	0.127	0.460	2.625	0.127	-
Oplismenus compositus	-	4.20 (1.18)	-	-	-	-	0.363	-	-	-
Panicum paludosum	4.00 (0.84)	9.28 (3.90)	2.55 (2.74)	-	6.38 (2.94)	0.258	0.133	0.586	-	0.166
Parthenium hysterophorus	0.92 (0.04)	0.75 (0.06)	0.51 (0.06)	-	-	1.000	0.375	1.500	-	-
Paspalum distichum	-	-	2.72 (1.96)	-	-	-	-	0.085	-	-
Paspalum scrobiculatum	-	-	0.97 (0.34)	-	-	-	-	0.530	-	-
Peristrophe bicalyculata	3.21 (0.58)	2.12 (0.40)	1.38 (0.66)	3.22 (0.14)	1.86 (0.38)	0.230	0.280	0.097	0.390	0.120
Perotis indica	-	-	1.22 (0.38)	-	-	-	-	1.055	-	-
Phaseolus sub-lobatus	-	0.96 (0.10)	-	-	-	-	0.276	-	-	-
Phyla nodiflora	-	0.75 (0.06)	-	-	-	-	0.375	-	-	-
Phyllanthus fraternus	-	2.57 (0.52)	1.92 (1.22)	-	2.44 (0.58)	-	1.107	1.135	-	0.857
Phyllanthus urinaria	-	4.01 (1.14)	3.36 (3.08)	-	12.22 (7.70)	-	0.197	0.174	-	0.140

(Continue)..

(Continued)

Phyllanthus virgatus	-	2.29 (0.46)	-	-	1.26 (0.18)	-	0.234	-	-	0.091
Physalis minima	-	-	0.68 (0.18)	-	-	-	-	0.500	-	-
Polycarpaea arvensis	-	1.96 (0.34)	1.17 (0.54)	-	2.77 (0.68)	-	0.340	0.275	-	0.346
Polygonum plebeium	-	2.07 (0.30)	1.74 (0.96)	-	-	-	0.061	0.489	-	-
Portulaca loppacea	-	0.96 (0.10)	0.52 (0.10)	-	-	-	0.276	0.625	-	-
Pycnocoma minima	-	1.20 (0.14)	0.85 (0.26)	-	1.56 (0.26)	-	0.388	0.080	-	0.080
Rivea hypocrateriformis	-	-	-	-	0.74 (0.06)	-	-	-	-	0.375
Rostellularia mollissima	-	-	0.79 (0.22)	-	-	-	-	0.610	-	-
Rostellularia quinqueangularis	-	-	1.68 (0.36)	-	-	-	-	0.860	-	-
Rungia pectinata	24.23 (12.22)	29.31 (18.26)	7.92 (10.54)	16.24 (2.26)	6.30 (2.36)	0.223	0.190	0.156	0.041	0.145
Rungia repens	38.48 (22.26)	32.21 (20.54)	10.78 (16.14)	21.27 (3.38)	11.84 (7.38)	0.222	0.205	0.218	0.044	0.168
Saccharum spontaneum	-	-	0.95 (0.28)	-	-	-	-	0.776	-	-
Sclerocarpus africanus	-	0.75 (0.04)	0.62 (0.26)	-	-	-	1.000	0.260	-	-
Sesamum orientale	-	0.73 (0.06)	0.46 (0.10)	-	-	-	0.166	0.276	-7	-
Sesbania bispinosa	-	0.77 (0.06)	-	-	-	-	0.387	-	-	-
Setaria glauca	-	3.61 (0.92)	10.46 (15.48)	-	4.14 (1.46)	-	0.117	0.191	-	0.215

(Continue)..

(Continued)

Setaria verticillata	-	-	3.13 (2.38)	--	-	-	-	0.075	-	-
Sida acuta	-	-	0.73 (0.22)	-	-	-	-	0.112	-	-
Sida cordata	4.15 (0.70)	3.47 (0.82)	1.14 (0.52)	5.71 (0.50)	4.25 (1.30)	0.068	0.091	0.160	0.103	0.052
Sida cordifolia	7.24 (2.02)	5.33 (1.62)	3.17 (2.66)	12.60 (1.66)	2.80 (0.66)	0.114	0.091	0.115	0.061	0.056
Sida rhombifolia	-	-	0.57 (0.14)	-	-	-	-	0.388	-	-
Sida spinosa	-	-	0.66 (0.18)	-	-	-	-	0.500	-	-
Sonchus brachyotus	-	1.20 (0.14)	0.65 (0.18)	-	-	-	0.388	0.281	-	-
Sonchus luteppense	-	-	0.51 (0.06)	-	-	-	-	1.500	-	-
Spergula arvensis	-	-	0.75 (0.16)	-	-	-	-	1.000	-	-
Sporobolus marginatus	-	-	0.28 (0.04)	-	-	-	-	0.250	-	-
Stellaria media	-	-	0.67 (0.14)	-	-	-	-	0.875	-	-
Tephrosia pumila	1.80 (0.20)	-	6.32 (7.62)	7.14 (0.56)	1.68 (0.32)	0.138	-	0.139	0.029	0.162
Tephrosia strigosa	-	3.30 (0.80)	4.74 (5.08)	-	-	-	0.118	0.287	-	-
Tetramnus labialis	-	-	1.11 (0.34)	-	-	-	-	0.943	-	-
Trianthema portulacastrum	1.61 (0.16)	-	-	-	-	0.443	-	-	-	-
Tribulus terrestris	-	0.96 (0.10)	1.50 (0.82)	-	1.09 (0.15)	-	0.276	0.142	-	0.218

(Continue)..

S-II : Abelmoschus manihot, Brachiaria kurzii, Celosia argentea, Convolvulus arvensis, Corchorus fascicularis, Corchorus trilocularis, Crotalaria prostrata, Indigofera linifolia, I.oblongifolia, Ipomoea eriocarpa, Phyla nodiflora, Ludwigia octovalvis, Oplismenus compositus, Phaseolus sub-lobatus, Sesbania bispinosa, and Urena lobata.

S-III : Abelmoschus crinitus, Acalypha ciliata, A.indica, Adhatoda vesica, Alysicarpus bupleurifolius, Anisomeles indica, Argemone mexicana, Azanza lampas, Barleria cristata, B.strigosa, Boerhavia verticillata, Bothriochloa pertusa, Cayratia trifolia, Chloris virgata, Cissampelos pariera, Cocculus hirsutus, Commelina paludosa, Coronopus didymus, Cyperus alopecuroides, C.iria, C.kyllingia, C.rotundus, Dactyloctenium aristatum, Dipteracanthus beddomei, Echinochloa crus-galli, Eclipta prostrata, Eragrostiella bifaria, Eragrostis diarrhena, E.poaeoides, Eremopogon foveolatus, Eriochloa procera, Gomphrena celosioides, G.globosa, Gynandropsis pentaphylla, Heteropogon contortus, Indigofera hirsuta, Ipomoea arachnosperma, Ischaemum laxum, Leucas aspera, Malva parviflora, Melanocenchris jacquemontii, Melochia corchorifolia, Mukia maderaspatana, Ocimum basilicum, Oldenlandia

affinis, Paspalum distichum, P.scrobiculatum, Perotis indica, Physalis minima, Rostellularia quinquecangularis, R.mollissima, Saccharum spontaneum, Setaria verticillata, Sida acuta, S.rhombifolia, S.spinosa, Sorghum halepense, Spergula arvensis, Sporobolus marginatus, Stellaria media, Teramnus labialis, and Trichosanthes cucumerina.

S-IV : Mil.

S-V : Alysicarpus longifolius, Desmodium triflorum, Ipomoea alba, Merremia aegyptia, Rivea hypocrateriformis, and Veronica agrestis.

The higher percentage of species present in frequency class A in all the sites studied indicate that the species on ground layer with poor dispersion were too much in numbers than the number of species with higher frequency values (Table - 3.4b).

The percentage of species falling under each of the frequency classes in S-I, S-II, S-III, S-IV and S-V and also of the Raunkiaer's normal are represented by histograms in Fig. - 3.3

The overall notation of frequency classes in each of the five locations as compared with that of Raunkiaer's world normal[339] can be expressed ut infra :

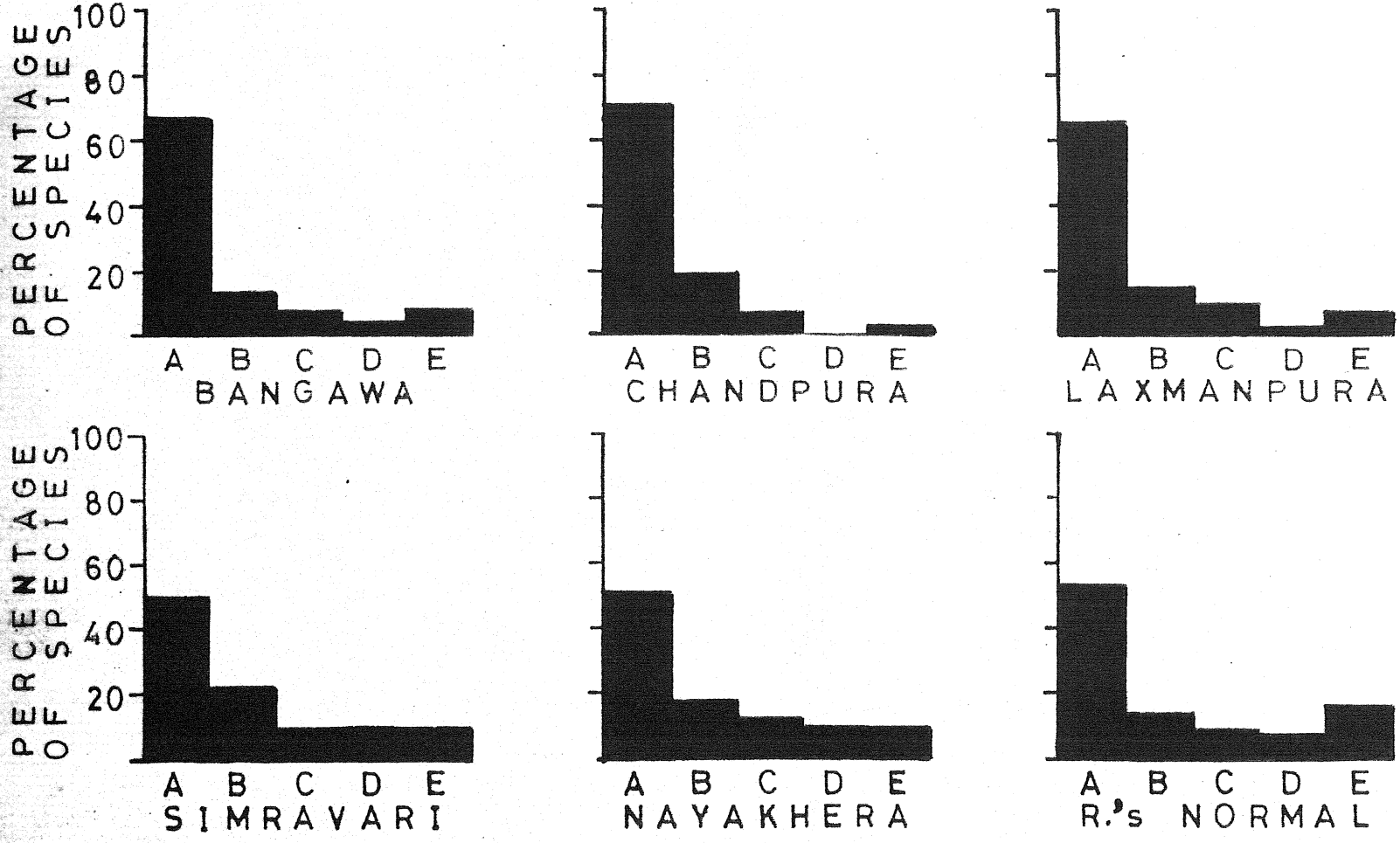


FIG. 3.3 - THE RELATIONSHIP BETWEEN FREQUENCY CLASS AND THE PERCENTAGE OF HERBACEOUS SPECIES FALLING WITHIN EACH OF THE CLASSES IN FIVE DIFFERENT FOREST BLOCKS AND THE RAUNKIAER'S WORLD NORMAL.

TABLE - 3.4.(b) PERCENTAGE DISTRIBUTION OF FREQUENCY CLASSES OF THE GROUND VEGETATION PRESENT IN FIVE DIFFERENT FOREST BLOCKS.

FREQUENCY CLASS	PERCENT DISTRIBUTION				
	S - I	S - II	S - III	S - IV	S - V
A	66.67	70.79	64.44	50.00	51.56
B	13.73	19.10	15.56	21.88	17.19
C	7.84	6.74	10.37	9.37	12.50
D	3.92	-	2.22	9.37	9.38
E	7.84	3.37	7.41	9.37	9.38
TOTAL SPECIES :	51	89	135	32	64

LEGEND : S - I : Bangawa S - II : Chandpura S - III : Laxmanpura
S - IV : Simravari S - V : Nayakhera

TABLE - 3.4.(c) INDEX OF SIMILARITY AND DISSIMILARITY BETWEEN FIVE COMMUNITIES OF THE GROUND VEGETATION.

SITES	INDEX OF SIMILARITY AND DISSIMILARITY			
S - II	0.5000			
	(0.5000)			
S - III	0.4194	0.5179		
	(0.5816)	(0.4821)		
S - IV	0.6265	0.4463	0.3473	
	(0.3735)	(0.5537)	(0.6527)	
S - V	0.6261	0.6405	0.4824	0.5208
	(0.3739)	(0.3595)	(0.5176)	(0.4792)
SITES	S - I	S - II	S - III	S - IV

NOTE : Values in parenthesis are of dissimilarity otherwise of similarity.

LEGEND : S - I : Bangawa S - II : Chandpura S - III : Laxmanpura S - IV : Simaravari S - V : Nayakhera

S-I	:	A	>	B	>	C	>	D	<	E
S-II	:	A	>	B	>	C	>	D	<	E
S-III	:	A	>	B	>	C	>	D	<	E
S-IV	:	A	>	B	>	C	=	D	=	E
S-V	:	A	>	B	>	C	>	D	=	E
A.'s Normal	:	A	>	B	>	C	≥ ≤	D	<	E

Regarding density of the ground vegetation, Laxmanpura block was most luxuriant and densely populated with 296.56 plants per square meter of area, whereas, Simravari block was least dense with only 39.38 plants/m^2. In other forests the values, as calculated, were 100.38, 103.18 and 155.22 plants/m^2 for Bangawa, Chandpura and Nayakhera blocks respectively.

Most densely populated and the dominant species in each of the five sites was : Mungia repens in Bangawa with 22.26 plants/m^2 and 38.48 IVI, and also in Chandpura with 20.54 plants/m^2 and 32.41 IVI; Cassia pumila in Laxmanpura with 22.78 plants/m^2 and 14.03 IVI; Oplismenus burmanii in Simravari with 6.24 plants/m^2 and 31.60 IVI; and Lindernia ciliata in Nayakhera with 22.58 plants/m^2 and 27.26 IVI.

Phytographs of three most dominant species in the community structure of five different forest blocks are prepared in Fig. - 3.4

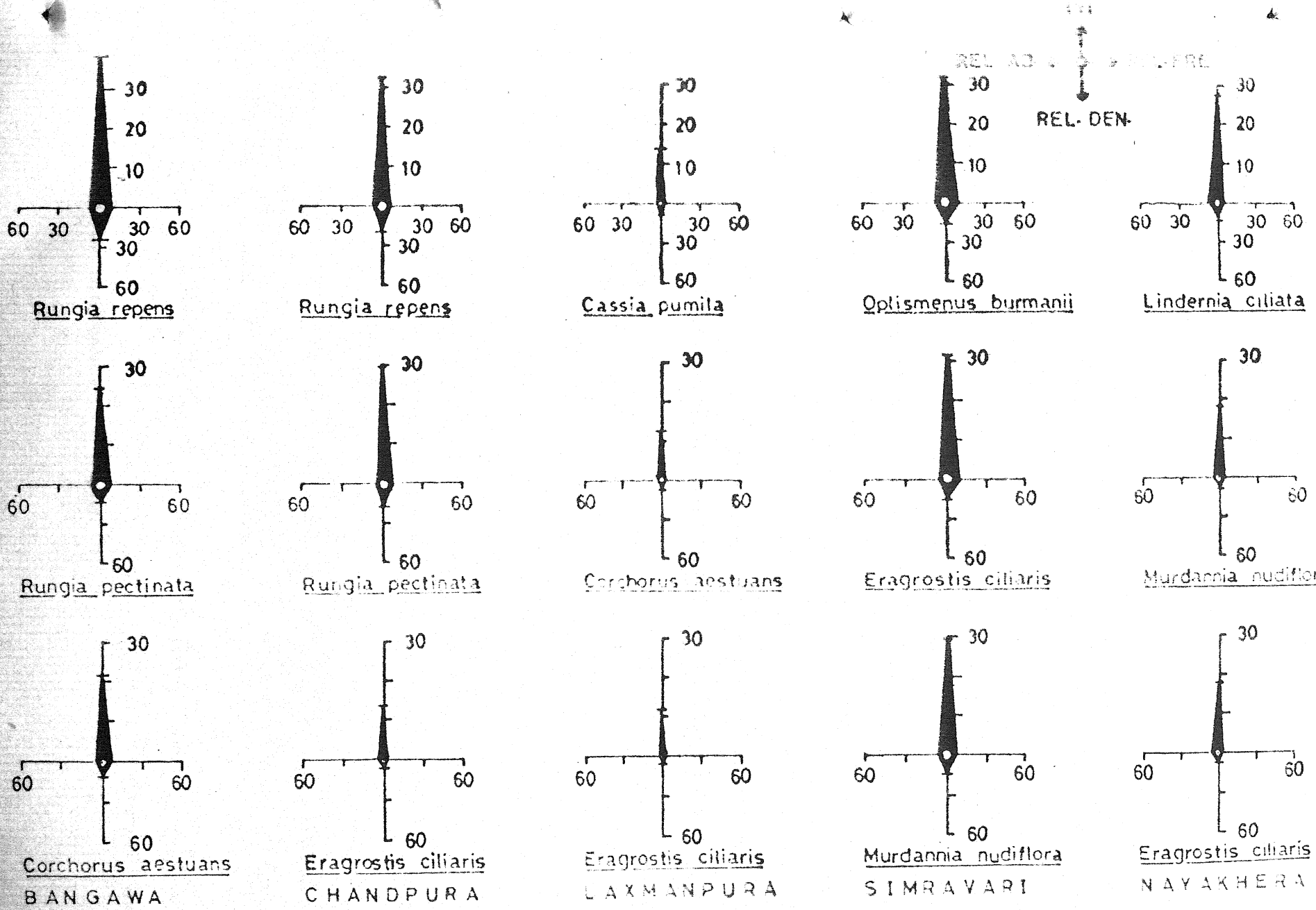


FIG. 3.4 PHYTOGRAPHS OF THE THREE MOST DOMINANT HERBACEOUS SPECIES OF GROUND LAYER IN THE COMMUNITY STRUCTURE OF FIVE DIFFERENT FOREST BLOCKS DOMINATED BY ANOGEISSUS PENDULA TREES.

The distribution patterns on the basis of A/V ration suggest that none of the ground layer species was irregularly spread. Further, only seven species out of a total 176 were randomly scattered in one or two sites, as rests, their contagious diffusion in other sites. These were : Cyperus niveus (S-IV), Ipomoea pes-tigridis (S-IV), Aungia pectinata (S-IV), A.repens (S-IV), Triumfetta rhomboidea (S-II), T. rotundifolia (S-I & S-V) and Tephrosia pumila (S-IV).

3.4(b) P R O D U C T I V E Q U A L I T Y

WHILE assessing productive quality or health of each tree species on the basis of Jai-Sun Index, the results, as documented in Table - 3.3 suggest that A.pendula trees were generally poor in their average quality in Bangawa forest, but were fair in their average health in rest of the sites with Jai-Sun values of 0.011 (D^+ level), 0.035, 0.026, 0.028 and 0.032 (all C^+ level) respectively.

Only four species of the trees were found in excellent quality (A^+ level), viz., Ficus benghalensis (S-II and S-V)*, Ficus infectoria (S-II)*, Ficus religiosa (S-II and S-V)* and Salmalia malabarica (S-I). In relation to sites, Laxmanpura and Simravari blocks were devoid of trees attaining excellent health. In addition to this, none of the tree species was superior (A level) in health in any of the five sites assessed.

The succeeding 9 and 11 species of trees were very good (B$^+$ level) and good (B level) respectively in their faculties, viz., Albizia lebbek (S-I), Azadirachta indica (S-I), Bassia latifolia (S-I), Boswellia serrata S-V)*, Butea monosperma (S-III), Cordia myxa (S-V), Holoptelia integrifolia (S-I), Salmalia malabarica (S-II and S-III), and Sterculia urens (S-III) were of very good ranking, whereas, Azadirachta indica (S-IV and S-V), Bassia latifolia (S-IV), Butea monosperma (S-I, S-II, S-IV and S-V), Ficus hispida (S-II)*, Grewia asiatica (S-V)*, Holoptelia integrifolia (S-II, S-III, S-IV and S-V), Mallotus phillipinensis (S-I)*, Salmalia malabarica (S-V), Sterculia urens (S-V), Tamarindus indica (S-I and S-II) and Terminalia tomentosa (S-I and S-V)* were of good reputation.

Fair quality (C$^+$ level) of trees were noticed to occur in some of the forest blocks. These 20 species were viz., Acacia catechu (S-V), Albizia lebbek(S-III), Albizia odoratissima (S-I), Albizia procera (S-I and S-III), Anogeissus latifolia (S-II and S-V)*, A.pendula (S-II, S-III, A.sericea (S-V)*, Azadirachta indica (S-II), Bassia latifolia (S-V), Bridelia retusa (S-V), Cassia fistula (S-I), Lagerstroemia parviflora (S-V), Lannea coromandelica (S-III and S-V), Pithecellobium dulce (S-II)*, Pterocarpus marsupium (S-V)*, Sapindus laurifolius (S-V), Sterculia urens (S-II),

Tamarindus indica (S-IV), Terminalia belerica (S-I) and Wrightia tinctoria (S-V).

Satisfactory robustness (C level) was observed in 26 tree species present in some sites. These were viz., Acacia catechu (S-I, S-II, S-III and S-IV), Acacia leucophloea (S-I, S-II, S-III and S-V), Aegle marmelos (S-II and S-V)*, Albizia lebbek (S-V), Albizia odoratissima (S-III and S-V), Albizia procera (S-II and S-V), Balanites aegyptiaca (S-III and S-V), Bridelia retusa (S-II), Cassia fistula (S-II and S-V), Cordia myxa (S-II), Diospyros melanoxylon (S-II and S-V)*, Emblica officinalis (S-II)*, Feronia limonia (S-V)*, Garuga pinnata (S-II and S-V)*, Lagerstroemia parviflora (S-II) Lannea coromandelica (S-II), Millingtonia hortensis (S-II, S-III and S-V)*, Mimusops hexandra (S-II)*, Mitragyna parviflora (S-V), Syzygium cumini (S-V), Randia dumetorum (S-II), Sapindus laurifolius (S-II), Terminalia arjuna (S-II and S-V)*, Terminalia belerica (S-II), Wrightia tinctoria (S-I and S-III) and Wrightia tomentosa (S-V),

On the basis of their Jai-Sun values, 21 tree species were poor in strength (D^+ level) ut infra : Acacia nilotica (S-I, S-II, S-III, S-IV, and S-V)*, Ailanthus excelsa (S-II)*, Alangium lamarckii (S-I, S-II and S-V), Albizia lebbek (S-II), Albizia odoratissima (S-II), Anogeissus

pendula (S-I), Anona squamosa (S-V), Balanites aegyptiaca (S-II), Bassia latifolia (S-II), Bauhinia racemosa (S-II, S-III and S-V), Helicterus isora (S-II)*, Mimosa rubicaulis (S-II and S-V)*, Mitragyna parviflora (S-III), Nyctanthes arbor-tristis (S-II, S-III and S-V), Ougenia dalbergioides S-II), Randia dumetorum (S-II), Tectona grandis (S-I, S-II and S-V)*, Wrightia tinctoria (S-II)Wrightia tomentosa (S-II), Zizyphus mauritiana (S-I, S-II, S-III and S-V)* and Zizyphus xylopyrus (S-I, S-II, S-III and S-V)*.

Only five species of the trees exhibited very poor (D level) disposition in some of the sites. They were : Anona squamosa (S-II). Bauhinia racemosa (S-I and S-IV) Nyctanthes arbor-tristis (S-I) Prosopis spicigera (S-II)*, and Zizyphus nummularia (S-I, S-II and S-IV)*.

Asterick mark (*) on the names of some tree species is just to specify that those species were entirely of the said quality irrespective of their sites of appearances. On the basis of percentage values site-wise health of the trees were analysed in Table 3.5 and are depicted in Fig. 3.5

Average values for the productive qualities of each of the five sites were different. Bangawa block with 25 tree species was poor in character with Jai-Sun value

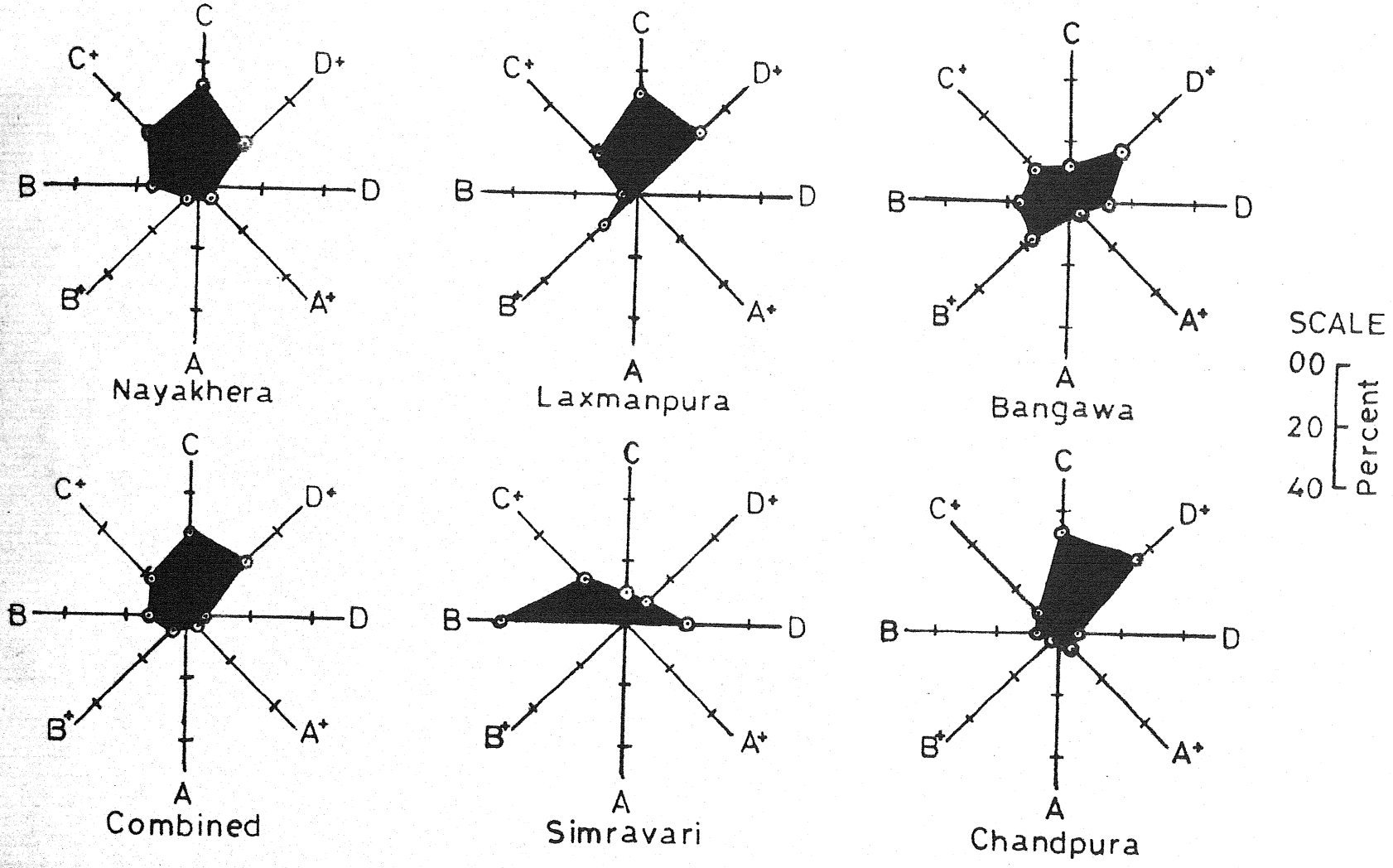


FIG. 3.5 PERCENTAGE OF TREES PRESENT IN EACH OF THE FIVE SITES AND AS COMBINED ON THE BASIS OF THEIR PRODUCTIVE QUALITY (JAI-SUN INDEX).

TABLE - 3.5 . PERCENTAGE AND TOTAL NUMBER OF THE TREE SPECIES OCCURRED UNDER VARIOUS QUALITY - CLASSES OR PRODUCTIVE LEVELS ON THE BASIS OF THEIR JAI - SUN VALUES IN DIFFERENT FOREST BLOCKS.

PRODUCTIVE QUALITY/LEVEL		FOREST BLOCKS					TOTAL
		BANGAWA	CHANDPURA	LAXMANPURA	SIMRAVARI	NAYAKHERA	
Excellent	A^+	4	5.9	-	-	4.3	3.9
		(1)	(3)	-	-	(2)	(6)
Superior	A	-	-	-	-	-	-
		-	-	-	-	-	-
Very good	B^+	16	2.0	14.3	-	4.3	6.5
		(4)	(1)	(3)	-	(12)	(10)
Good	B	16	7.8	4.8	40	15.2	13.1
		(4)	(4)	(1)	(4)	(7)	(20)
Fair	C^+	16	9.8	19.0	20	23.9	17.0
		(4)	(5)	(4)	(2)	(11)	(26)
Satisfactory	C	12	33.3	33.3	10	32.6	28.1
		(3)	(17)	(7)	(1)	(15)	(43)
Poor	D^+	24	35.3	28.6	10	19.6	26.2
		(6)	(18)	(6)	(1)	(9)	(40)
Very poor	D	12	5.9	-	20	-	5.2
		(3)	(3)	-	(2)	-	(8)

NOTE : Values in parenthesis are of the numbers of tree species otherwise of the percentage of total species present in the concerned block.

of 0.015 only. Chandpura (51 tree species), Simravari (10 species) and Nayakhera (46 species) each of these three blocks was fair (C+ level) in their reputation with Jai-Sun values 0.028, 0.027 and 0.031 respectively. Laxmanpura forest with 21 species was satisfactory (C level) in its strength with Jai-Sun values 0.025 . The general sturdiness of these forests can be arranged in the following descending sequence ad val. : Nayakhera > Chandpura > Simravari > Laxmanpura > Bangawa.

3.4(c) P L A N T A N D L I F E - F O R M S

THIS study is an out come of intensive explorations and regular field trips of the five forest sites through all the seasons. The forest blocks surveyed were Bangawa, Chandanpura, Laxmanpura, Simravari, and Nayakhera, frequent inspections of these area yielded a total of 512 plant species which were appropriately assigned to their life-form classes and other plant-forms viz., growth and migrule forms and sociability classes. The biological spectrum and other qualitative assessments of plant-forms are recorded in Table - 3.6 This presents appears to be the first to record the floristics of the local forest sites by means of the biological spectrums.

The life-form classes viz., Phanerophytes,

TABLE - 3.6 BIOLOGICAL SPECTRUM AND OTHER QUALITATIVE ASSESSMENTS OF THE COMPONENT SPECIES STATING THEIR HABIT; LIFE, GROWTH AND MIGRULE FORMS; SOCIABILITY CLASS; AND STRATIFICATION IN THE FLORA OF SOME FOREST AREA STUDIED IN JHANSI AND ITS ADJOINING RANGES.

NAME AND FAMILY OF THE COMPONENT SPECIES	HABIT	LIFE FORM	GROWTH FORM	MIGRULE FORM	SOCIABILITY CLASS	STRATIFICATION CLASS
RANANCULACEAE						
Ranunculus sceleratus Linn.	A	Th	e-b	D_2	S_2	E
ANONACEAE						
Anona squamosa Linn.	P	Ph	e-b	D_2	S_2	C
MENISPERMACEAE						
Cissampelos pareira Linn.	P	Th	tw-b	D_1	S_1	C
Cocculus villosus DC.	P	Th	cl	D_2	S_1	C
Tinospora cordifolia Miers.	P	Ph	cl	D_2	S_1	C
NYMPHAEACEAE						
Nymphaea nouchali Burm.f.	P	G	e-rh	D_1-D_5	S_3	E
Nymphaea stellata Willd.	P	G	e-rh	D_1-D_5	S_3	E
NELUMBONACEAE						
Nelumbo nucifera Gaertn.	P	G	e	D_1-D_5	S_2	E
PAPAVERACEAE						
Argemone mexicana Linn.	A	Th	e-b	D_2	S_1	E
FUMARIACEAE						
Fumaria indica (Hausk.) Pugsley	A	Ch	p-b	D_2	S_1	E
BRASSICACEAE						
Coronopus didymus (Linn.) Smith	A-Bi	Ch	p-b-r	D_2	S_1	E
Rorippa nasturtium-aquaticum (Linn.)Hayek.	A-Bi	G	p-b-rh	D_3-D_5	S_1	E
Sisymbrium irio Linn.	A	Th	e-b	D_2	S_1	E
CLEOMACEAE						
Gleome viscosa Linn.	A	Th	e	D_2	S_1	E
Gynandropsis pentaphylla DC.	A	Th	e	D_2	S_1	E

(Continue)

CAPPARIDACEAE						
Capparis aphylla Roth.	P	Ph	e-b	D_2-D_4	S_1	D
Capparis sepiaria Linn.	P	Ph	e-b	D_2-D_4	S_1	D
Capparis zeylanica Linn.	P	Ph	Cl	D_2	S_1	D
RESEDACEAE						
Oligomeris linifolia (Vahl.) Macb.	A	Th	e-b	D_1	S_2	E
VIOLACEAE						
Hybanthus enneaspermus (Linn.) Muell.	A-P	Ch	p-b	D_1-D_2	S_2	E
Viola cinerea Boiss.	P	Ch	p-b	D_1-D_2	S_2	E
FLACOURTIACEAE						
Flacourtia ramontchi Herit.	P	Ph	e-b	D_2-D_4	S_2	D
POLYGALACEAE						
Polygala arvensis Willd.	A	Ch	p-b	D_1	S_1	E
Polygala crotalarioides Buch.-Ham. ex DC.	P	Th	e-b	D_1	S_1	E
CARYOPHYLLACEAE						
Drymaria cordata (Linn.) Willd. ex Roem. & Schult.	A	Ch	p-b	D_2	S_1	E
Polycarpon prostratum (Forsk.) Asch. & Schw.	A-Bi	Ch	p	D_2	S_1	E
Spergula arvensis Linn.	A	Ch	p	D_1-D_2	S_2	E
Stellaria media (Linn.) Vill.	A	Ch	p	D_2	S_2	E
PORTULACEAE						
Portulaca quadrifida Linn.	A	Th	p-b	D_1	S_2	E
TAMARISCINACEAE						
Tamarix dioica Roxb.	P	Ph	e-b	D_2	S_1	D
Tamarix gallica Linn.	P	Ph	e-b	D_1-D_2	S_1	D
ELATINACEAE						
Bergia ammannioides Heyne ex Roth.	A	Ch	p	D_1	S_2	E
MALVACEAE						
Abelmoschus crinitus Wall.	A	Th	e	D_2	S_1	E
Abelmoschus manihot (Linn.) Medik.	P	Ph	e-b	D_1-D_2	S_1	D
Abelmoschus moschatus Medik.	P	Th	e-b	D_1	S_1	E
Abutilon indicum (Linn.) Sw.	A-P	Th	e-b	D_2	S_1	E

(Continue)

Azanza lampas (Cav.) Alef.	A	Th	e	D_1-D_2	S_2	E
Hibiscus lobatus (Murr.) Kuntze	A	Th	e-b	D_2	S_1	E
Hibiscus micranthus Linn.f.	A	Th	e-b	D_1	S_1	E
Malachra capitata Linn.	A-P	Th	e-b	D_2	S_2	E
Malva parviflora Linn.	A	Ch	p-b	D_1-D_2	S_2	E
Malvastrum coromandelianum (Linn.) Garcke	P	Ch	p-b	D_2	S_2	E
Sida acuta Burm.f.	P	Th	e-b	D_2	S_1	E
Sida cordata (Burm.f.) Borss.	P	Ch	p-tr	D_2	S_2	E
Sida cordifolia Linn.	A-P	Th	e-b	D_1-D_2	S_2	E
Sida rhombifolia Linn.	A	Th	e-b	D_1-D_2	S_1	E
Sida spinosa Linn.	A	Th	e-b	D_1-D_2	S_1	E
Urena lobata Linn.	P	Th	e-b	D_2	S_2	E
Urena repanda Roxb. ex Sm.	P	Th	e-b	D_2	S_2	E
BOMBACACEAE						
Salmalia malabarica (DC) Schott. & Endl.	P	Ph	ps-e-b	D_1-D_2	S_1	A
STERCULIACEAE						
Helicteres isora Linn.	P	Ph	e-b	D_1	S_2	D
Melochia corchorifolia Linn.	A	Th	e-b	D_1-D_2	S_2	B
Sterculia urens Roxb.	P	Ph	e-b	D_1-D_4	S_2	B
TILIACEAE						
Corchorus aestuans Linn.	A	Th	e-b	D_1-D_2	S_1	E
Corchorus capsularis Linn.	A	Th	e-b	D_1-D_2	S_1	E
Corchorus depressus (Linn.) Stocks	P	Ch	p-t	D_1-D_2	S_1	E
Corchorus fascicularis Lamk.	A-P	Th	e	D_2	S_1	E
Corchorus olitorius Linn.	A	Th	e-b	D_2-D_4	S_1	E
Corchorus tridens Linn.	A	Th	e	D_2	S_1	E
Corchorus trilocularis Linn.	A-P	Th	e-b	D_2	S_1	E
Grewia asiatica Linn.	P	Ph	e-b	D_2-D_4	S_1	C
Grewia exoelsa Vahl.	P	Ph	e-b	D_2	S_1	C
Grewia tenax (Forsk.) Fiori	P	Ph	e-b	D_1	S_1	C
Grewia villosa Willd.	P	Ph	e-b	D_1-D_2	S_1	C
Triumfetta pilosa Roth.	A-P	Th	e-b	D_2	S_2	E
Triumfetta rhomboidea Jacq.	A	Th	e-b	D_2	S_2	E
Triumfetta rotundifolia Lamk.	A	Th	p	D_1-D_2	S_2	E

(Continue)

(Continued)

LINACEAE						
Linum usitatissimum Linn.	A	Th	e-(b)	D_1-D_2	S_1	E
MALPIGHIACEAE						
Hiptage madablota Gaertn.	P	Ph	Cl	D_1-D_2	S_1	C
ZYGOPHYLLACEAE						
Fagonia cretica Linn.	A	Th	e-b	D_1	S_1	E
Tribulus terrestris Linn.	A-Bi	Ch	p-b-ps	D_1-D_2	S_2	E
OXALIDACEAE						
Biophytum reinwardtii (Zucc.) Klotz.	A	Th	e-r	D_1-D_3	S_2	E
Biophytum sensitivum (Linn.) DC.	A	Th	e-r	D_1-D_3	S_1	E
Oxalis corniculata Linn.	P	G	p-rh	D_1-D_5	S_3	E
RUTACEAE						
Aegle marmelos Corr.	P	Ph	e-b	D_2-D_5	S_2	B
Clausena pentaphylla (Roxb.) DC	P	Ph	e-b	D_2	S_1	C
Feronia limonia (Linn.) Swing.	P	Ph	e-b	D_2-D_4	S_1	A
SIMARUBACEAE						
Ailanthus excelsa Roxb.	P	Ph	e-b-r	D_2	S_1	B
Balanites aegyptiaca (Linn.) Delile	P	Ph	e-b	D_2-D_5	S_2	B
BURSERACEAE						
Boswellia serrata Roxb. ex Colebr.	P	Ph	e-b-ps	D_2-D_5	S_2	A
Garuga pinnata Roxb.	P	Ph	e-b	D_2-D_5	S_1	C
MELIACEAE						
Azadirachta indica Juss.	P	Ph	e-b	D_1-D_2	S_1	B
Melia azedarach Linn.	P	Ph	e-b	D_1-D_2	S_1	B
Soymida febrifuga Juss.	P	Ph	e-b	D_2-D_5	S_1	B
CELASTRACEAE						
Celastrus senegalensis Lamk.	P	Ph	e-b	D_2	S_2	D
Celastrus spinosus Royle.	P	Ph	e-b	D_2	S_2	D
RHAMNACEAE						
Ventilago maderaspatana Gaertn.	P	Ph	Cl	D_1-D_4	S_1	B
Zizyphus mauritiana Lamk.	P	Ph	e-b	D_2-D_4	S_2	C
Zizyphus nummularia (Burm.f.) Wt. & Arn.	P	Ph	e-b	D_2-D_5	S_2	D
Zizyphus oenoplia (Linn.) Mill.	P	Ph	Cl	D_2-D_4	S_2	C
Zizyphus xylopyrus (Retz.) Willd.	P	Ph	e-b	D_2-D_4	S_1	C

(Continue)..

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VITACEAE						
Cayratia trifolia (Linn.),Domin.	A-P	Th	Cl-b	D_2-D_4	S_2	D
Leea macrophylla Roxb. ex Hornem.	P	Th	e	D_2-D_4	S_1	E
Vitis quadrangularis Wall.	P	Ph	Cl-tw	D_4-D_5	S_1	B
SAPINDACEAE						
Cardiospermum halicacabum Linn.	A-P	Th	Cl	D_1-D_4	S_1	E
Sapindus laurifolius Vahl.	P	Ph	e-b	D_2-D_4	S_1	B
ANACARDIACEAE						
Buchanania latifolia Roxb.	P	Ph	e-b	D_2-D_5	S_1	B
Lannea coromandelica (Houtt.) Merr.	P	Ph	e-b	D_2-D_4	S_2	B
Rhus mysurensis Heyne ex Wt. & Arn.	P	Ph	r-tr	D_2	S_1	D
PAPILIONACEAE						
Abrus precatorius Linn.	A	Th	tw-b	D_2-D_4	S_2	C
Aeschynomene indica Linn.	A	Th	e-b	D_2-D_4	S_2	E
Alhagi camelorum Fisch	A	Th	e-b	D_2-D_4	S_1	E
Alysicarpus bupleurifolius (Linn.) DC	A	Ch	p-b	D_2	S_3	E
Alysicarpus hamosus Edgew.	A	Ch	p	D_2	S_2	E
Alysicarpus longifolius Wt. & Arn.	A	Th	e-b	D_2-D_4	S_3	E
Alysicarpus monilifer (Linn.) DC	P	Ch	p-t	D_2	S_3	E
Alysicarpus rugosus (Willd.) DC	A	Ch	(e)-p-b	D_2	S_3	E
Alysicarpus tetragonolobus Edgew.	A	Ch	p-b	D_2	S_2	E
Alysicarpus vaginalis (Linn.) DC	A-P	Ch	p-b	D_2	S_2	E
Atylosia albicans (Wt. & Arn.) Benth.	A	Th	tw-b	D_2	S_2	E
Atylosia scarabaeoides (Linn.) Benth.	A-P	Th	tw-tr	D_2	S_3	E
Butea monosperma (Lamk.) Taub.	P	Ph	e-b	D_2-D_4	S_2	B
Butea superba Roxb.	P	Ph	Cl-b	D_2-D_4	S_2	C
Canavalia ensiformis DC.	Bi-P	Th	Cl-b	D_2	S_1	D
Crotalaria albida Heyne ex Roth.	P	Th	e-b	D_2	S_2	E
Crotalaria medicaginea Lamk.	A	Th	e-(b)	D_2	S_2	E
Crotalaria prostrata Rottl. ex Willd.	P	Ch	p	D_2	S_2	E
Crotalaria retusa Linn.	A	Th	e	D_2	S_1	E
Dalbergia latifolia Roxb.	P	Ph	e-b	D_2-D_5	S_2	B
Dalbergia paniculata Roxb.	P	Ph	e-b	D_2-D_5	S_1	B
Dalbergia sissoo Roxb.	P	Ph	e-b	D_2-D_5	S_1	B
Desmodium gangeticum (Linn.) DC.	P	Ch	p	D_1	S_2	E

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Desmodium neo-mexicanum	A	Th	e	D_1	S_2	E
Desmodium triflorum (Linn.) DC.	P	Ch	p	D_1	S_2	E
Dumasia villosa DC.	A	Th	Cl	D_1-D_2	S_1	E
Heylandia latibrosa DC	P	Ch	p-b	D_1-D_2	S_1	E
Indigofera cassioides Rottl. ex DC.	P	Th	e-b	D_2	S_2	E
Indigofera cordifolia Heyne ex Roth.	A	Ch	p-b(e)	D_1	S_2	E
Indigofera hirsuta Linn.	A-Bi	Th	e	D_2	S_1	E
Indigofera linifolia (Linn.f.) Retz.	P	Ch	p-b	D_1	S_2	E
Indigofera linnaei Ali	A-P	Ch	p	D_1	S_2	E
Indigofera oblongifolia Forsk.	A	Th	e-b	D_1-D_2	S_1	E
Indigofera tinctoria Linn.	A-P	Th	e-b	D_1-D_2	S_1	E
Indigofera trita Linn.f.	A	Th	e-b	D_1	S_1	E
Lathyrus aphaca Linn.	A	Ch	p-tr	D_1	S_2	E
Lathyrus sativus Linn.	A	Ch	tr	D_1	S_2	E
Mauchania macrophylla (Willd.) Kuntze.	A	Ch	p-b	D_1	S_2	E
Mauchania strobilifera (Linn.) J.St.-Hil. ex Kuntze	A-P	Ch	p	D_1	S_2	E
Medicago polymorpha Linn.	A	Ch	p	D_2-D_3	S_3	E
Melilotus indica (Linn.) All.	A-Bi	Th	e-b	D_1-D_2	S_2	E
Milletia auriculata Baker ex Brand.	P	Ph	Cl-b	D_2-D_4	S_1	C
Mucuna pruriens (Linn.) DC.	A	Th	tw	D_1-D_2	S_2	D
Ougenia dalbergioides Benth.	P	Ph	e-b	D_2-D_5	S_2	B
Phaseolus sub-lobatus Roxb.	A	Th	tw	D_1-D_2	S_2	E
Psoralea corylifolia Linn.	A	Th	e-b	D_2	S_2	E
Pterocarpus marsupium Roxb.	P	Ph	e-b	D_2-D_5	S_2	B
Pueraria tuberosa (Roxb. ex Willd.) DC.	A-P	Ph	tw	D_2-D_4	S_2	D
Rhynchosia capitata DC	A	Th	tr	D_2	S_1	E
Rhynchosia minima (Linn.) DC.	A-P	Th	tw-(p)	D_2-D_4	S_1	E
Rothia indica (Linn.) Druce	A	Ch	p-b	D_1	S_2	E
Sesbania bispinosa (Jacq.) Wight	A	Th	e-b	D_2	S_2	E
Smithia conferta Smith	A-P	Ch	p-b	D_2	S_2	E
Tephrosia pumila (Lamk.) Pers.	A	Ch	p-b	D_2-D_4	S_2	E
Tephrosia purpurea (Linn.) Pers.	P	Th	e-b	D_1-D_2	S_2	E
Tephrosia strigosa (Dalz.) Santap & Mahesh	A	Th	e	D_1	S_1	E
Tephrosia villosa (Linn.) Pers.	A	Th	e-b	D_1	S_1	E
Teramnus labialis Spreng.	A	Th	Cl-b	D_2	S_1	E

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Vicia faba Linn.	A	Th	e-b	D_1-D_2	S_2	E
Vicia sativa Linn.	A	Ch	p-Cl	D_1-D_2	S_2	E
Zornia gibbosa Span.	A	Ch	p	D_1-D_2	S_3	E
CAESALPINIACEAE						
Bauhinia racemosa Lamk.	P	Ph	e-b-ps	D_2-D_4	S_2	C
Bauhinia tomentosa Linn.	P	Ph	e-b	D_2	S_1	C
Bauhinia vahlii Wt. & Arn.	P	Ph	Cl-p	D_1-D_4	S_1	B
Cassia absus Linn.	A	Th	e-b	D_1-D_2	S_1	E
Cassia fistula Linn.	P	Ph	e-b	D_2-D_5	S_1	B
Cassia mimosoides Linn.	A	Ch	p-(e)-b	D_1-D_2	S_2	E
Cassia obtusifolia Linn.	A	Th	e	D_1-D_2	S_2	E
Cassia occidentalis Linn.	A-P	Th	e	D_1-D_2	S_2	E
Cassia pumila Lamk.	A	Ch	p-(eb)	D_1-D_2	S_3	E
Cassia sophera Linn.	A-P	Th	e	D_2	S_1	E
Cassia tora Linn.	A	Th	e	D_1-D_2	S_3	E
Tamarindus indica Linn.	P	Ph	e-b	D_2-D_5	S_1	A
MIMOSACEAE						
Acacia catechu Willd.	P	Ph	e-b	D_1-D_4	S_3	B
Acacia leucophloea (Roxb.) Willd.	P	Ph	e-b	D_1-D_4	S_1	B
Acacia nilotica (Linn.) Willd. ex Delile	P	Ph	e-b	D_1-D_4	S_2	B
Albizzia lebbek (Linn.) Willd.	P	Ph	e-b	D_1-D_4	S_2	B
Albizzia odoratissima (Linn.f.) Benth.	P	Ph	e-b	D_1-D_5	S_1	B
Albizzia procera (Roxb.) Benth.	P	Ph	e-b	D_1-D_5	S_1	B
Dichrostachys cinerea Wt. & Arn.	P	Ph	e-b	D_1-D_5	S_1	D
Mimosa hamata Willd.	A-P	Th	e-b	D_1-D_2	S_1	D
Mimosa pudica Linn.	A-P	Ch	p	D_1-D_5	S_1	E
Mimosa rubicaulis Lamk.	A-P	Th	e-b	D_1-D_2	S_2	D
Pithecellobium dulce (Roxb.) Benth.	P	Ph	e-b	D_1-D_2	S_2	B
Prosopis juliflora (Sw.) DC.	P	Ph	e-b	D_1	S_2	D
Prosopis spicigera Linn.	P	Ph	e-b	D_1-D_5	S_2	D
COMBRETACEAE						
Anogeissus latifolia (DC.) Wall. ex Bedd.	P	Ph	e-b	D_1-D_5	S_2	B
Anogeissus pendula Edgew.	P	Ph	e-b	D_1-D_5	S_4	B
Anogeissus sericea Brand.	P	Ph	e-b	D_1-D_5	S_2	B
Terminalia arjuna Bedd.	P	Ph	e-b	D_2-D_4	S_1	A

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Terminalia belerica Roxb.	P	Ph	e-b	D_2-D_4	S_1	B
Terminalia chebula Retz.	P	Ph	e-b	D_2-D_4	S_1	B
Terminalia tomentosa Wt. & Arn.	P	Ph	e-b	D_2-D_5	S_1	A
MYRTACEAE						
Eugenia heyneana Duthie	P	Ph	e-b	D_1-D_5	S_2	B
LYTHRACEAE						
Ammannia baccifera Linn.	A-P	Th	e-b	D_1	S_3	E
Lagerstroemia parviflora Roxb.	P	Ph	e-b	D_1-D_4	S_2	D
Woodfordia fruticosa (Linn.) Kurz.	P	Ph	e-b	D_1-D_4	S_2	D
ONAGRACEAE						
Ludwigia octovalvis (Jacq.) Raven	P	Th	e	D_1	S_3	E
Ludwigia perennis Linn.	P	Th	e	D_1	S_2	E
Ludwigia prostrata Roxb.	A	Ch	p	D_1	S_2	E
CUCURBITACEAE						
Blastania garcinia (Linn.) Cogn.	A	Th	Cl	D_2	S_1	D
Cucumis trigonus Roxb.	A	Th	p-b-tw	D_2-D_4	S_1	D
Diplocyclos palmatus (Linn.) Jeff.	A	Th	Cl	D_1-D_2	S_1	D
Mukia maderaspatana (Linn.) Roem.	A	Th	Cl	D_1-D_2	S_1	D
Trichosanthes bracteata (Lamk.) Voigt.	P	Th	Cl	D_2	S_1	D
Trichosanthes cucumerina Linn.	A	Th	Cl	D_2	S_1	D
CACTACEAE						
Opuntia elatior Mill.	P	Ph	e	D_2-D_5	S_2	E
Opuntia vulgaris Mill.	P	Ph	e-b	D_2-D_5	S_2	D
AIZOACEAE						
Trianthema monogyna Linn.	A	Ch	p-b	D_1	S_2	E
Trianthema pentandra Linn.	A	Ch	p	D_1	S_2	E
Trianthema portulacastrum Linn.	A	Ch	p	D_1	S_2	E
MOLLUGINACEAE						
Glinus lotoides Linn.	A	Ch	p-b	D_1	S_1	E
Glinus oppositifolius (Linn.) DC.	A	Ch	p	D_1	S_1	E
Mollugo cerviana (Linn.) Ser.	A	Th	e-b	D_1	S_2	E
Mollugo nudicaulis Lamk.	A	He	p	D_1	S_1	E
Mollugo pentaphylla Linn.	A	Ch	p-(e)-b	D_1	S_1	E
APIACEAE						
Centella asiatica (Linn.) Urban	P	G	e-rh	D_1-D_5	S_2	E

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ALANGIACEAE						
Alangium lamarckii Thw.	P	Ph	e-b	D_2-D_5	S_2	C
RUBIACEAE						
Borreria articularis (Linn.f.) Williams	A-P	Ch	(e)-p	D_1	S_1	E
Borreria brachystema (R.Br. ex Benth.) Valet	A	Th	e	D_1	S_2	E
Gardenia latifolia Ait	P	Ph	e-b	D_2	S_1	B
Mitragyna parviflora (Roxb.) Korth.	P	Ph	e-b	D_1	S_2	B
Oldenlandia affinis	A	Ch	p	D_1	S_1	E
Oldenlandia corymbosa Linn.	A-Bi	Ch	p-(e)	D_1	S_2	E
Oldenlandia diffusa (Willd.) Roxb.	A	Ch	p	D_1	S_1	E
Oldenlandia nudicaulis Roth.	A	Th	e-(b)	D_1	S_1	E
Pavetta indica Linn.	P	Ph	e	D_2	S_1	D
Randia dumetorum Lamk.	P	Ph	e-b	D_2-D_5	S_1	B
ASTERACEAE						
Acanthospermum hispidum DC	A	Th	e-b	D_1	S_1	E
Adenostemma lavenia (Linn.) Kuntze	A	Ch	p	D_1	S_1	E
Ageratum conyzoides Linn.	A	Th	e	D_1-D_2	S_2	E
Bidens bipinnata Linn.	A	Th	e-(b)	D_1	S_2	E
Blainvillea acmella (Linn.) Phil.	A	Th	e-(b)	D_1	S_1	E
Blumea fistulosa (Roxb.) Kurz.	A	Th	e	D_1	S_1	E
Blumea lacera (Burm.f.) DC.	A-Bi	Th	e	D_1	S_2	E
Blumea mollis (Don.) Merr.-Phil.	A-Bi	Ch	p-(e)	D_1	S_1	E
Blumea oxyodonta DC.	A-Bi	Ch	p-(b)	D_1	S_2	E
Caesulia axillaris Roxb.	A	G	p-(e)	D_1	S_2	E
Carthamus oxyacantha Bieb.	A	Th	e-b	D_1	S_1	E
Centipeda minima (Linn.) A.Br. & Asch.	A	He	p-b	D_1	S_2	E
Centratherum anthelminticum (Linn.) Kuntze	A	Th	e-(b)	D_1	S_1	E
Cichorium intybus Linn.	A-P	He	e-rh	D_1	S_2	E
Echinops echinatus Roxb.	A-Bi	Th	e-b	D_1-D_2	S_1	E
Eclipta prostrata (Linn.) Linn.	A	Ch	p-b	D_1	S_1	E
Elephantopus scaber Linn.	A-P	G	p-(e)-rh	D_1-D_5	S_1	E
Emilia sonchifolia (Linn.) DC.	A-P	Th	e	D_1	S_1	E
Flaveria contrayerba	A	Th	p	D_1	S_1	E
Glossocardia bosvallea (Linn.f.) DC.	A	Ch	p-b	D_1	S_1	E
Gnaphalium luteo-album Linn.	A	Th	e-b	D_1	S_2	E

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Grangea maderaspatana Poir.	A	He	p-rh	D_1	S_1	E
Lagascea mollis Cav.	A	Ch	p	D_1	S_1	E
Laggera aurita Sch.-Bip. ex Clarke	P	Th	e-b	D_1	S_2	E
Launea acaulis (Roxb.) Bab. ex Craib	P	Ch	t	D_1	S_2	E
Launea asplenifolia (Willd.) Hook.f.	A-Bi	Th	e-t-(b)	D_1	S_2	E
Launea procumbens (Roxb.) Ramay. & Rajagopal.	P	He	p-rh	D_1	S_1	E
Parthenium hysterophorus Linn.	A-Bi	Th	e-b	D_1	S_3	E
Pulicaria crispa Sch.-Bip. et Webb & Benth.	A	Th	r	D_1	S_1	E
Sclerocarpus africanus Jacq. ex Murr.	A	Th	e-b	D_1	S_1	E
Siegesbeckia orientalis Linn.	A-Bi	Th	e-b	D_1	S_1	E
Sonchus brachyotus DC.	P	He	e-rh	D_1	S_2	E
Sphaeranthus indicus Linn.	A	Ch	p	D_1	S_1	E
Spilanthes acmella (Linn.) Murr.	A	Th	e	D_1	S_1	E
Tridax procumbens Linn.	A-Bi	Th	e-(p)	D_1	S_2	E
Vernonia cinerea (Linn.) Less.	A-P	Th	e-b	D_1	S_1	E
Vicoa indica (Linn.) DC.	P	Th	e-b	D_1	S_1	E
Volutarella divaricata Benth. & Hook.f.	A	Th	e-b	D_1	S_1	E
Xanthium strumarium Linn.	A-Bi	Th	e-b	D_1	S_2	E
Youngia japonica (Linn.)DC.	A-Bi	He	e-rh	D_1	S_1	E
MYRSINACEAE						
Myrsine africana Linn.	P	Ph	Cl	D_1	S_1	B
PRIMULACEAE						
Anagallis arvensisLinn.	A	Ch	p-(e)-b	D_1	S_2	E
SAPOTACEAE						
Bassia latifolia Roxb.	P	Ph	e-b	D_2	S_2	B
Mimusops hexendra Roxb.	P	Ph	e-b	D_2	S_1	B
EBENACEAE						
Diospyros melanoxylon Brand.	P	Ph	e-b	D_2-D_5	S_2	B
OLEACEAE						
Nyctanthes arbor-tristis Linn.	P	Ph	e-b	D_2	S_1	C
APOCYNACEAE						
Carissa carandas Linn.	P	Ph	e-b	D_2	S_1	D
Carissa spinarum Linn.	P	Ph	e-b	D_2	S_1	D
Ichnocarpus frutescens (Linn.) Ait & Ait.f.	P	Ph	Cl	D_2-D_4	S_1	B

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Wrightia tinctoria R.Br.	P	Ph	e-b	D_2-D_5	S_2	B
Wrightia tomentosa Roem & Schult.	P	Ph	e-b	D_2	S_1	B
ASCLEPIADACEAE						
Calotropis procera (Willd.) Dry. ex Ait.	P	Th	e-b	D_1-D_2	S_1	D
Cryptolepis buchnani Roem & Schult.	A-Bi	Th	tw	D_2-D_4	S_1	C
Daemia extensa R.Br.	P	Th	tw	D_1	S_1	C
Dregea volubilis Benth. ex Hook.f.	A-P	Ph	tw	D_1	S_1	C
Gymnema sylvestre (Retz.) R.Br. ex Schult.	P	Th	Cl	D_1-D_2	S_2	C
Hemidesmus indicus R.Br.	A	Th	tw-(p)	D_1	S_1	C
Oxystelma esculentum R.Br.	P	Th	Cl	D_1	S_1	C
Telosma pallida (Roxb.) Craib.	P	Th	tw	D_1	S_1	C
GENTIANACEAE						
Enicostema hyssopifolium (Willd.) Verd.	A	Th	e	D_1-D_4	S_2	E
Hoppea dichotoma Hayne ex Willd.	A	Th	e-b	D_2	S_1	E
BORAGINACEAE						
Coldenia procumbens Linn.	A	Ch	p-tr	D_2	S_1	E
Cordia myxa Linn.	P	Ph	e-b	D_2-D_4	S_1	B
Heliotropium indicum Linn.	A	Th	p-b(e)	D_1	S_1	E
Heliotropium strigosum Willd.	A-P	Ch	p-b	D_1	S_1	E
Trichodesma amplexicaule Roth.	A	Th	ps	D_1	S_1	E
CONVOLVULACEAE						
Convolvulus arvensis Linn.	A	Ch	p-b	D_1	S_1	E
Evolvulus alsinoides (Linn.)Linn.	A	Ch	p	D_1-D_2	S_1	E
Ipomoea alba Linn.	A	Th	tw	D_1	S_1	E
Ipomoea arachnosperma Welw.	A	Th	tw	D_1-D_2	S_1	E
Ipomoea coptica (Linn.) Roth ex Roem & Schult.	A	Th	p	D_1	S_1	E
Ipomoea eriocarpa R.Br.	A	Ch	p-tw	D_1	S_1	E
Ipomoea pes-tigridis Linn.	A	Ch	tw	D_1-D_2	S_2	E
Ipomoea sindica Stapf.	A	Th	p-tr	D_1	S_1	E
Merremia aegyptia (Linn.) Urban	A	Ch	p-tw	D_1-D_2	S_1	C
Rivea hypocrateriformis Choisy	A	Th	Cl	D_2-D_4	S_1	D
CUSCUTACEAE						
Cuscuta reflexa Roxb.	A	Th	tw	D_5	S_3	D
SOLANACEAE						
Datura stramonium Linn.	A-P	Th	e-b	D_2	S_1	E

(Continue)..

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Lycium barbarum Linn.	A-P	Th	e-b	D_2	S_1	E
Physalis minima Linn.	A	Th	e-(b)	D_2	S_1	E
Solanum nigrum Linn.	A-P	Ch	p-(e)-b	D_2	S_1	E
Solanum surattense Burm.f.	A-P	Ch	p-b	D_2	S_1	E
Withania somnifera (Linn.) Dunal.	A	Th	e-b	D_2	S_1	E
SCROPHULARIACEAE						
Bacopa monnieri (Linn.) Penn.	P	Ch	tr-p	D_1	S_2	E
Kickxia ramosissima (Wall.) Janchen.	A	Th	e-b	D_2-D_4	S_2	E
Lindenbergia indica (Linn.) Kuntze	A	Th	e-b	D_1	S_2	E
Lindernia ciliata (Colsm) Penn.	A	he	e-(b)	D_1	S_1	E
Lindernia crustacea(Linn.) Muell.	A	He	p-b	D_1	S_1	E
Scoparia dulcis Linn.	A-P	Th	e-b	D_1	S_1	E
Striga asiatica (Linn.) Kuntze	A	Th	e-b	D_1	S_1	E
Verbascum chinense (Linn.) Santap.	A	Th	e	D_1	S_2	E
Verbascum thapsus Linn.	A	Th	e-(b)	D_1	S_2	E
Veronica agrestris Linn.	A	Ch	p	D_1	S_1	E
GESNERIACEAE						
Rhynchoglossum obliquum Bl.	A	Ch	e	D_1-D_3	S_1	E
PEDALIACEAE						
Sesamum orientale Linn.	A	Th	e-b	D_2	S_1	E
MARTYNIACEAE						
Martynia annua Linn.	A	Th	e-b	D_2	S_2	E
BIGNONIACEAE						
Millingtonia hortensis Linn.f.	P	Ph	e-b	D_1-D_5	S_1	A
ACANTHACEAE						
Adhatoda vasica Nees	A-Bi	Th	e-b	D_1	S_3	E
Andrographis echioides (Linn.) Nees	A	Th	e	D_1	S_2	E
Barleria cristata Linn.	P	Th	e	D_2	S_1	E
Barleria prionitis Linn.	P	Th	e	D_2	S_1	E
Barleria strigosa Willd.	P	Th	e	D_2	S_1	E
Blepharis molluginifolia Pers.	A	Ch	p-b	D_1	S_1	E
Dipteracanthus beddomei (Clarke) Santap.	P	Th	e-b	D_2	S_2	E
Elytraria acaulis (Linn.f.) Lindau	A	He	p	D_1	S_2	E
Hygrophila auriculata (Schum.) Heine	P	Ch	p-b	D_1	S_1	E

(Continue)..

(Continued)

Lepidagathis incurva Buch.-Ham. ex D.Don	P	Ch	pr	D_3-D_5	S_1	E
Nelsonia canescens (Lamk.) Spreng.	P	He	p-rh	D_1	S_1	E
Peristrophe bicalyculata (Retz.) Nees	A	Th	e-b	D_3	S_3	E
Rostellularia mollissima (Nees) Nees	A	Ch	p	D_1	S_2	E
Rostellularia quinqueangularis (Koenig ex Roxb.) Nees	A	Ch	p	D_1	S_2	E
Rungia pectinata (Linn.) Nees	A	Ch	p	D_1	S_2	E
Rungia repens (Linn.) Nees	A	Ch	p	D_1	S_2	E
VERBENACEAE						
Clerodendrum indicum (Linn.) Kuntze	P	Th	e-b	D_1	S_2	E
Lantana camara Linn.	P	Th	e	D_1	S_1	D
Phyla nodiflora (Linn.) Greene	P	Ch	p-b	D_1	S_1	E
Tectona grandis Linn.	P	Ph	e-(b)	D_1-D_4	S_3	B
Vitex negundo Linn.	P	Ph	e-b	D_1-D_5	S_2	C
LAMIACEAE						
Anisochilus carnosus (Linn.) Wall.	A	Th	e	D_1-D_2	S_1	E
Anisomeles indica (Linn.) Kuntze	A-P	Th	e	D_1	S_1	E
Hyptis suaveolens (Linn.) Poit	A-P	Th	e-b	D_1-D_2	S_3	E
Leucas aspera	A	Th	e	D_2	S_1	E
Leucas cephalotes (Roth.) Spreng.	A	Th	e-b	D_2	S_2	E
Leucas mollissima Wall.	A	Th	e-b	D_2	S_1	E
Nepeta hindostana (Roth.) Haines	A-P	Ch	p-b	D_1-D_2	S_2	E
Ocimum basilicum Linn.	A	Th	e-b	D_1-D_2	S_2	E
Ocimum gratissimum Linn.	A-P	Th	e-b	D_1-D_2	S_2	E
Orthosiphon pallidus Royle ex Benth.	A-P	Th	e-b	D_1-D_2	S_2	E
NYCTAGINACEAE						
Boerhavia diffusa Linn.	P	Ch	p-b	D_2	S_1	E
Boerhavia erecta Linn.	A	Ch	p-(e)	D_2	S_1	E
Boerhavia verticillata	A-P	Ch	p	D_2	S_1	E
AMARANTHACEAE						
Achyranthes aspera Linn.	A-P	Th	e	D_2	S_2	E
Aerva javanica (Burm.f.) Juss. ex Schult.	A	Th	e-b	D_1	S_1	E
Aerva lanata (Linn.) Juss.	P	Ch	p	D_1-D_2	S_2	E
Aerva sanguinolenta (Linn.) Bl.	P	Th	e	D_2	S_1	E
Alternanthera puncens H.B. & K.	A	Th	e-b	D_1	S_1	E
Alternanthera sessilis (Linn.) DC	A-P	Ch	p-(e)	D_2	S_2	E

(Continue)..

(Continued)

Amaranthus spinosus Linn.	A-P	Th	e-b	D_1-D_2	S_1	E
Amaranthus viridis Linn.	A	Th	e-b	D_1	S_1	E
Celosia argentea Linn.	A	Th	e-b	D_1-D_2	S_2	E
Digera muricata (Linn.) Mart.	A	Th	e-b	D_2	S_1	E
Gomphrena celosioides Mart.	A-P	Ch	p-(e)	D_1-D_2	S_2	E
Gomphrena globosa Linn.	A	Ch	p	D_1	S_1	E
Nothosaerva brachiata (Linn.) Wt.	A	Th	e-b	D_1	S_1	E
Pupalia lappacea (Linn.) Juss.	A	Th	e-b	D_2	S_2	E
CHENOPODIACEAE						
Salsola baryosma (Roem & Schult.) Dandy	A	Th	e-b	D_1-D_2	S_2	E
Suaeda maritima (Linn.) Dumort.	A	Th	e-b	D_1-D_2	S_2	E
POLYGONACEAE						
Polygonum barbatum Linn.	A-P	Th	e-(p)	D_1-D_3	S_2	E
Polygonum glabrum Willd.	A-P	Th	e-b	D_1-D_3	S_1	E
Polygonum plebeium R.Br.	A	Ch	p-b	D_1-D_3	S_2	E
Rumex dentatus Linn.	A	Th	e-b	D_1	S_2	E
LORANTHACEAE						
Dendrophthoe falcata (Linn.f.) Etting.	A	Th	e	D_1	S_3	B
Viscum articulatum Burm.f.	A	Th	e	D_1	S_2	B
EUPHORBIACEAE						
Acalypha ciliata Forsk.	A	Th	e-b	D_1	S_1	E
Acalypha indica Linn.	A-P	Th	e-b	D_1	S_1	E
Bridelia retusa Spreng.	P	Ph	e-b	D_1-D_5	S_2	B
Chrozophora parvifolia Klotz. ex Schw.	A	Ch	p-b	D_1	S_1	E
Chrozophora prostrata	A	Ch	p-b	D_1	S_1	E
Chrozophora rottleri (Geisler) Sprengel.	A	Th	e-b	D_1	S_1	E
Emblica officinalis	P	Ph	e-b	D_2	S_1	B
Euphorbia dracunculoides Lamk.	A	Th	e-b	D_1	S_2	E
Euphorbia geniculata Orteg.	A	Th	e-b	D_1	S_1	E
Euphorbia granulata Forsk.	A	Ch	p-b	D_1	S_1	E
Euphorbia hirta Linn.	A	Th	e	D_1	S_1	E
Euphorbia prostrata Ait.	A	Ch	p	D_1	S_2	E
Euphorbia thymifolia Linn.	A	Ch	p-b	D_1	S_1	E
Jatropha gossypifolia Linn.	P	Th	e-b	D_1-D_2	S_1	E
Mallotus philippinensis Muell.	P	Ph	e-b	D_2-D_5	S_1	B

(Continued)..

(-v))

(Continued)

Phyllanthus fraternus Webster.	A	Th	e-b	D_1-D_3	S_1	E
Phyllanthus urinaria Linn.	A	Ch	p-b	D_1-D_3	S_2	E
Phyllanthus virgatus Forst.	P	Ch	p-b	D_1-D_3	S_2	E
Ricinus communis Linn.	A-P	Th	e	D_2	S_2	E
ULMACEAE						
Holoptelea integrifolia Planch.	P	Ph	e-b	D_1-D_2	S_2	A
MORACEAE						
Ficus benghalensis Linn.	P	Ph	e-b	D_2-D_4	S_1	A
Ficus hispida Linn.	P	Ph	e-b	D_2-D_5	S_1	B
Ficus infectoria Roxb.	P	Ph	e-b	D_2-D_4	S_1	A
Ficus religiosa Linn.	P	Ph	e-b	D_2-D_4	S_1	A
CANNABACEAE						
Cannabis sativa Linn.	A-P	Th	e-b	D_2	S_2	E
ZINZIBERACEAE						
Costus speciosus (Koenig ex Retz.) Smith	P	G	e-rh	D_2	S_1	E
DIOSCOREACEAE						
Dioscorea pentaphylla Linn.	P	G	tw-rh	D_2-D_5	S_1	D
LILIACEAE						
Gloriosa superba Linn.	A-P	G	Cl-b-rh	D_2-D_5	S_1	D
COMMELINACEAE						
Amischophacelus axillaris (Linn.)Rao & Kamm.	A	Ch	p-(e)	D_1	S_1	E
Commelina benghalensis Linn.	A	Th	p	D_1	S_2	E
Commelina diffusa Burm.f.	A	G	p-rh	D_1	S_1	E
Commelina forskalii Vahl.	A	G	p-(e)-rh	D_1	S_2	E
Commelina kurzii Cl.	A	Ch	p	D_1	S_2	E
Commelina paludosa Bl.	A	Ch	p	D_1	S_1	E
Murdannia nudiflora (Linn.) Brenan	A	Ch	p	D_1	S_2	E
Murdannia spirata (Linn.) Bruckn.	A	Ch	p	D_1	S_2	E
CYPERACEAE						
Bulbostylis barbata (Rottb.) Clarke	A	G	p-(e)	D_1	S_1	E
Carex fedia Nees	A	He	p	D_1	S_1	E
Cyperus alopecuroides Rottb.	A	G	p-(e)	D_1	S_1	E
Cyperus brevifolius (Rottb.) Hask.	P	G	rh	D_1-D_5	S_2	E

(Continue)..

(Continued)

Cyperus bulbosus Vahl.	A	Th	p	D_1	S_1	E
Cyperus compressus Linn.	A	Th	e	D_1	S_1	E
Cyperus corymbosus (Linn.) Kuntze	A	Th	e	D_1	S_1	E
Cyperus iria Linn.	A	Th	e	D_1	S_1	E
Cyperus kyllingia Endl.	P	He	rh-p	D_1-D_5	S_2	E
Cyperus niveus Retz.	P	He	rh-p	D_1-D_5	S_2	E
Cyperus rotundus Linn.	P	G	e-rh	D_1-D_5	S_1	E
Cyperus triceps (Rottb.) Endl.	P	He	rh-p	D_1-D_5	S_2	E
Kleocharis ortopurpurea (Retz.) Kunth.	A	G	e-rh	D_1	S_1	E
Fimbristylis dichotoma (Linn.) Vahl.	A	Th	e	D_1	S_1	E
Fimbristylis ferruginea (Linn.) Vahl.	A	G	e-(p)-rh	D_1	S_2	E
Fimbristylis monostachya (Linn.) Hassk.	A	Th	e	D_1	S_1	E
Fimbristylis quinquangularis (Vahl.) Kunth.	A	Th	e	D_1	S_1	E
Fimbristylis spathacea Roth.	A	G	e-rh	D_1	S_2	E
Scirpus littoralis Schrad.	A	G	e-rh	D_1	S_1	E
Scirpus roylei (Nees) Parker	A	G	e-rh	D_1	S_2	E
Soleria levis Retz.	P	G	rh-p-t	D_1-D_5	S_2	E

POACEAE

Acrachne racemosa (Heyne ex Roem & Schult) Ohwi.	A	Ch	e-t	D_1-D_2	S_1	E
Aeluropus lagopoides (Linn.) Trin. ex Thw.	A	Ch	p-t	D_1-D_2	S_1	E
Alloteropsis cimicina (Linn.) Stapf.	A	Ch	e-t	D_1-D_2	S_2	E
Apluda aristata Linn.	P	Th	e-t	D_2	S_2	E
Apluda mutica Linn.	P	Th	e-t	D_2	S_2	E
Aristida adscensionis Linn.	A	Th	e	D_2	S_3	E
Arundo donax Linn.	P	He	rh-p	D_2-D_5	S_2	E
Bothriochloa pertusa (Linn.) Camus	P	Ch	p-(e)-t	D_2	S_2	E
Brachiaria kurzii	A	Ch	p-t	D_1-D_2	S_2	E
Brachiaria reptans (Linn.) Gardn. & Hubb.	A-P	Ch	p-t	D_2	S_2	E
Capillipedium assimile (Steud.)) Camus	P	He	p-t	D_2	S_1	E
Cenchrus ciliaris Linn.	P	G	e-t	D_2-D_5	S_2	E
Cenchrus setigerus Vahl.	P	G	e-t	D_2-D_5	S_2	E
Chionachne koenigii (Spreng) Thw.	P	He	e-t	D_1-D_2	S_1	E
Chloris barbata Sw.	P	He	e	D_1-D_5	S_2	E
Chloris dolichostachya Lagas.	A-P	Ch	e-(p)	D_1	S_1	E
Chloris virgata (Linn.) Sw.	A	G	p-rh	D_1	S_1	E
Chrysopogon fulvus (Spreng.) Chiov.	P	He	e-t	D_1-D_2	S_2	E

(Continue)

(Continued)

Coix lacryma-jobi Linn.	A-P	G	e-rh	D_1-D_5	S_2	E
Cymbopogon martinii (Roxb.) Wats	P	Th	e	D_1	S_1	E
Cynodon dactylon (Linn.) Pers.	P	G	p	D_1-D_5	S_3	E
Cyrtococcum oxyphyllum (Steud.) Stapf.	P	Th	e	D_1	S_2	E
Dactyloctenium aegyptium (Linn.) Beauv.	A	Th	ps-t	D_1	S_2	E
Dactyloctenium aristatum Link.	A	Th	ps-t	D_1	S_2	E
Dactyloctenium sindicum	A	Th	ps-t	D_1	S_2	E
Dendrocalamus strictus (Roxb.) Nees	P	G	e-rh	D_2-D_5	S_3	E
Desmostachya bipinnata (Linn.) Stapf.	P	He	e-t	D_1-D_5	S_3	E
Dichanthium annulatum (Forsk.) Stapf.	P	He	e-t	D_1-D_5	S_3	E
Digitaria adscendens (HBK) Henr.	A	Th	e	D_2	S_1	E
Digitaria biformis Willd.	A	Ch	p	D_2	S_1	E
Dinebra retroflexa (Vahl.) Panz.	A	He	e-t	D_1-D_2	S_2	E
Echinochloa crus galli (Linn.) Beauv.	A	Ch	e	D_2	S_1	E
Eleusine indica (Linn.) Gaertn.	A-Li	He	p-t	D_1	S_2	E
Eragrostiella bifaria (Vahl.) Bor.	P	He	e-t	D_1	S_2	E
Eragrostis ciliaris (Linn.) R.Br.	A	Th	e	D_1-D_2	S_2	E
Eragrostis diarrhena (Schult.) Steud.	A	Ch	p	D_1-D_2	S_1	E
Eragrostis pilosa (Linn.) Beauv.	A	Th	e	D_1-D_2	S_2	E
Eragrostis poaeoides Beauv.	A	Th	e-t	D_1	S_1	E
Eragrostis tenella (Linn.) Beauv. ex Roem & Schult.	P	He	e	D_1	S_2	E
Eragrostis tremula Hochst. ex Steud.	A	Ch	p	D_1	S_1	E
Eragrostis uniloides (Retz.) Nees ex Steud.	A	Ch	P_D	D_1	S_1	E
Eragrostis viscosa (Retz.) Trin.	P	Ch	p-t	D_1-D_2	S_1	E
Eremopogon foveolatus (Delile) Stapf.	P	G	t-rh	D_1-D_2	S_1	E
Eriochloa procera (Retz.) Hubb.	A	He	p-t	D_1-D_2	S_1	E
Hackelochloa granularis (Linn.) Kuntze	A	Ch	e-t	D_1	S_1	E
Hemarthria compressa (Linn.f.) R.Br.	P	G	p-rh	D_1	S_1	E
Heteropogon contortus (Linn.) Beauv. ex Roem & Schult	A	G	e-rh	D_1	S_2	E
Imperata cylindrica (Linn.) Beauv.	P	G	p-rh	D_1	S_2	E
Iseilema laxum Hack.	P	He	e-t	D_1-D_5	S_3	E
Leptochloa panicea (Retz.) Ohwi	A	Ch	e	D_2	S_2	E
Lolium temulentum Linn.	A	Ch	e	D_2	S_1	E
Melanocenchris jacquemontii Jan. & Spach.	A	Ch	e	D_1	S_3	E
Ophiuros exaltatus (Linn.) Kuntze	P	Ch	p	D_1	S_1	E
Oplismenus burmannii (Retz.) Beauv.	A	He	p-t	D_2	S_2	E

(Continue)..

Chamaephytes, Hemicryptophytes, Geophytes and Therophytes were numerally represented in the forest area by 103, 128, 33, 37 and 211 plant species respectively. The percentage values of these life-form classes, as worked out, can be documented ut infra :

Phanerophytes	:	20.1 %
Chamaephytes	:	25.0 %
Hemicryptophytes	:	06.5 %
Geophytes	:	07.2 %
Therophytes	:	41.2 %

Thus, the region seems to be dominated by Therophytes. Chamaephytes were proxime accessit. In other a pegpres two-third of the total plant species gathered u these two life-form classes

The majority of the species were erect (57.8 and branched annuals (46.3 - 61.5%) with dissemination of their seeds mostly by wind or water (37.5%) or through animals (21.9%) or both (16.6%). Nearly all the annual pl species were found growing either isolated (53.1%) or for a small group (40.6%), whereas, the perenniels (38.3 - 4 most of which were either trees, shrubs, climbers or gra were growing in close associations and thereby forming c

open (04.1%) or close (02.2%) colonies (06.3%). The biennials contributed poorly with 0.2 - 4.1% of their shares in the total vegetation.

3.4(d) S T R A T I F I C A T I O N

The concept of stratification is of obvious importance in understanding the structure of the forest area. The stratification of the vegetation may range from two layers (a herb layer at ground level and canopy of the tree layer at top level) to a more complicated arrangements with a herb layer, several shrub and sapling layers and the overall top canopy of the tree layer.

The forest is usually divided into five layers viz., A, B, C, D, and E^{345}. These multistoried structure of the vegetation as constituted by the process of stratification and ultimately recognised as different layers in the stand are ut infra :

A-LAYER OR EMERGENT LAYER : The tier is otherwise called the 'Eco-dominant Tier', 'Top layer' or the 'Crown Canopy'. The trees forming this layer were generally stunted in their growth and they hardly attained a height of 10 m or more. The trees were scattered in the area

without any overlapping of crowns. Some of the common trees constituting this top tier were : Ficus benghalensis, Ficus religiosa, Ficus infectoria, Feronia limonia, Holoptelia integrifolia, Millingtonia hortensis, Salmalia malabarica, Terminalia arjuna and Terminalia tomentosa.

B-LAYER OR MIDDLE LAYER : This layer is also known as 'Co-dominant Tier', 'Sub-canopy' or Under storey'. Some of the plants falling under this layer of stratification developed a close colony. The common component species constituting the tier were : Acacia catechu, Albizia lebbek, Anogeissus pendula, Balanites aegyptiaca, Butea monosperma, Diospyros melanoxylon, Eugenia heyniana, Lagerstroemia parviflora, Lannea coromandelica, Mitragyna parviflora, Eugenia dalbergioides, Pterocarpus marsupium, Randia dumetorum, Sterculia urens, Tectona grandis, Wrightia tinctoria etc.

C-LAYER OR LOWER LAYER : This tier is also known as 'lower storey', 'Lower tier' or 'Lower canopy'. plants providing shapeliness to this tier were customarily under-trees, large shrubs

and top climbers including some twinners. They can be listed as : Alangium lamarckii, Bauhinia racemosa, Hystanthes arbor-tristis, Zizyphus mauritiana, Zizyphus xylopyrus, Vitex negundo etc., whereas, the twinners were: Abrus precatorius, Cissampelos pariera, Cocculus villosus, Gymnema sylvestre, Merremia aegyptia, Zizyphus oenoplia etc.

D-LAYER OR SHRUB LAYER : The forms of vegetation composing this fourth tier of stratification were extensively shrubs or bushes. Many of them were armed with thorns or spines. Some of the vulgar plant species contriving this layer were : Capparis aphylla, Celastrus senegalensis, Dichrostachys cinerea, Flacourtia ramontchi Helicteres isora, Lantana camara, Mimosa rubicaulis, Woodfordia fruticosa, Zizyphus nummularia etc.

The usual twinner and the climbers sharing this tier were : Blastania garcinia, Capparis zeylanica, Cayratia trifolia, Mucuna pruriens (Plate - 9), Mukia maderaspatana, Rhus mysurensis, Trichosanthes cucumerina etc.

5-LAYER OR GROUND LAYER : This last layer of the stratification is also known as 'Field layer' or the 'Ground flora'. The vegetation of this layer is rightly been considered as 'GUARDIAN OF THE SOIL'. It is actually the vestment of the Earth. The tier is framed of a few erect, sub-erect, prostrate or tufted herbs and undershrubs. Creepers, trailers and the grass also subscribe in making up this fifth and the last tier of the stratified vegetation. Some of the plant species ordinarily contained in this layer can be listed under sub-heads ut infra :

(a). UNDER-SHRUBS : Adhatoda vasica, Barleria prionitis, Corchorus triloculeris, Indigofera caesioides, Triumfetta rotundifolia etc.

(b). ERECT AND SUB-ERECT HERBS : Abutilon indicum, Achyranthes aspera, Bidens bipinnata, Cassia sophera, Cassia tora, Cleome viscosa, Corchorus aestuans, Desmodium gangeticum (Plate - 10), Digera muricata, Echinops echinatus, Hyptis suaveolens, Ludwigia perennis, Martynia annua, Melochia corchorifolia, Parthenium hysterophorus,

PLATE - 9. HORSE - EYE BEAN : *MUCUNA PRAURIENS* (LINN.) DC. OF FAMILY FABACEAE SHARING THE D - LAYER OR SHRUB LAYER IN A *ANOGEISSUS PENDULA* DOMINATED FOREST OF HINDELWAND REGION.

PLATE - 10. ONE OF THE CONSTITUENT MEMBERS OF THE E - LAYER OR FIELD LAYER IN THE STRATIFICATION OF *ANOGEISSUS PENDULA* FORESTS : *DESMODIUM GANGETICUM* (LINN.) DC. OF FAMILY FABACEAE.





Pupalia lappacea, Mungia repens (Plate - 11), Sida cordifolia, Tephrosia strigosa, Trichodesma amplexicaule, Tridax procumbens (Plate - 12), Triumfetta rhomboidea, Xanthium strumarium etc.

(c). DIFFUSE HERBS : Borgia axmannioides, Cassia pumila, Commelina benghalensis, Elytraria acaulis, Glinus lotoides, Hybanthus enneaspermus, Lepidagathis incurva, Mollugo cerviana, Phyla nodiflora, Polygonum plebeium, Stellaria media, Trianthema portulacastrum, Tribulus terrestris etc.

(d). CREEPERS AND TRAILERS : Atylosia scarabaeoides, Bacopa monnieri, Ipomoea pes-tigridis, Lathyrus aphaca, Rhynchosia capitata etc.

(e). SEDGES : Carex fedia, Cyperus brevifolius, Cyperus niveus, Fimbristylis dichotoma, Scleria levis, Scleria reylei etc.

(f). GRASS : Alloteropsis cimicina, Aplunda mutica, Brachiaria reptans, Cenchrus ciliaris, Chloris dolichostachya, Cynodon dactylon,







PLATE - 11. THE MOST DOMINATED HERBACEOUS SPECIES IN THE GROUND LAYERS OF BANDAMA AND CHANDPURA FOREST BLOCKS : RUNGIA REPENS (LINN.) HERB OF FAMILY ACANTHACEAE.

PLATE - 12. ONE OF THE RARE AND SUB - ERECT HERBS IN THE GROUND FLORA OF 'KANDHAI' FOREST : TRIDAX PROCUMBENS LINN. OF FAMILY ASTERACEAE. THIS HERBACEOUS SPECIES IS FOUND OCCURRING ONLY IN THE OPEN PARTS OF THE FOREST.





Dactyloctenium aegyptium, Eragrostis ciliaris, Heteropogon contortus, Melanocenchrus jacquemontii, Opliesmenus burmanii, Paspalum distichum, Perotis indica, Setaria glauca, Sorghum halepense, Sporobolus marginatus, Tragus biflorus etc.

3.5 S Y S T E M A T I C S

IN the present investigations for preparing the Biological spectrum etc., of the area, a total of 512 plant species were confiscated. These species represented 85 families and 336 genera including both the Dicotyledons and the Monocotyledons. The number of families, genera and their species comprising the division Dicotyledoneae can be further analysed ut infra :

(1). POLYPETALAE	:	Families	: 48,
		Genera	: 129, and
		Species	: 217,
(2). GAMOPETALAE	:	Families	: 22,
		Genera	: 111, and
		Species	: 138.
(3). MONOCHLAMYDEAE	:	Families	: 10,
		Genera	: 29, and
		Species	: 51.

Similarly, the members of the division Monocotyledoneae can also be further classified ut infra :

(1). PETALOIDEAE	:	Families	: 03,
		Genera	: 05, and
		Species	: 10.
(2). GLUMIFERAE	:	Families	: 02,
		Genera	: 62, and
		Species	: 96.

The details are provided in Table - 3.7(a).

The monotypic families, representing the area were 29 in numbers viz., Alangiaceae, Anonaceae, Apiaceae, Bignoniaceae, Bombacaceae, Cannabaceae, Cuscutaceae, Dioscoraceae, Ebenaceae, Elatinaceae, Flacourtiaceae, Fumariaceae, Gesneriaceae, Liliaceae, Linaceae, Malpighiaceae Martyniaceae, Myrsinaceae, Myrtaceae, Nelumbonaceae, Oleaceae, Papaveraceae, Pedaliaceae, Portulacaceae, Primulaceae, Ranunculaceae, Resedaceae, Ulmaceae and Zingiberaceae.

The monogeneric families represented in the same area were numerally 10 viz., Aizoaceae - (2), Cactaceae - (2), Capparidaceae - (3), Celastraceae - (2), Moraceae - (4), Nyctaginaceae - (3), Nymphaeaceae - (2), Onagraceae - (3),

TABLE - 3.7.(a) STATISTICAL SYNOPSIS OF THE VEGETATION OF SOME FOREST AREA STUDIED NEAR JHANSI.

GROUP	FAMILIES		GENERA		SPECIES	
	%	No.	%	No.	%	No.
DICOTS :						
1. Polypetalae	56.47	48	38.39	129	42.38	217
2. Gamopetalae	25.88	22	33.04	111	26.96	138
3. Monochlamydeae	11.77	10	8.63	29	9.96	51
MONOCOTS :						
1. Petaloideae	3.53	3	1.49	5	1.95	10
2. Glumiferae	2.35	2	18.45	62	18.75	96
TOTAL :	100.00	85	100.00	336	100.00	512

Polygalaceae - (2) and Tamariscinaceae - (2). The values in parenthesis are number of the species present in that unigeneric family. The name of the representative genera coming under the mentioned monogeneric family was : Trianthema, Opuntia, Capparis, Celastrus, Ficus, Boerhavia, Nymphaea, Ludwigia, Polygala and Tamarix respectively.

Cyperus appears to be the biggest genera of the area inspected. It consisted of 10 species (Table - 3.7b), viz., C.alopecuroides, C.brevifolius, C.bulbosus, C.compressus, C.corymbosus, C.iria, C.kyllingia, C.niveus, C.rotundus and C.tricops. Cassia, Eragrostis and Indigofera were proxime accessit as each of them were represented by 8 species. Secundum ordinem other genera with 5 or more species each were : Alysicarpus and Corchorus both 7 spe. each; Euphorbia and Ipomoea both 6 spe. each; and Commelina, Fimbristylis and Sida all with 5 spe. each (Table - 3.7b).

The largest families dominating the vegetation of the area were as follows : (arranged in a basipetal sequence) : Fabaceae (86 spe.) > Poaceae (75 spe.) > Asteraceae (40 spe.) > Cyperaceae (21 spe.) > Euphorbiaceae (19 spe.) > Malvaceae (17 spe.) > Acanthaceae (16 spe.) > Amaranthaceae (14 spe.) >

TABLE - 3.7.(b) BIGGEST GENERA HAVING FIVE OR MORE SPECIES EACH IN THE AREA STUDIED.

NAME OF THE GENERA	TOTAL SPECIES	
	NUMBER	NAME OF THE SPECIES
COMMELINA	5	C.benghalensis, C.diffusa, C.forskalii, C.kurzii, C.paludosa
FIMBRISTYLIS	5	F.dichotoma, F.ferruginea, F.monostachya, F.quinquangularis, F.spathacea
SIDA	5	S.acuta, S.cordata, S.cordifolia, S.rhombifolia, S.spinosa
EUPHORBIA	6	E.dracunculoides, E.geniculata, E.granulata, E.hirta, E.prostrata, E.thymifolia
IPOMOEA	6	I.alba, I.arachnosperma, I.coptica, I.eriocarpa, I.pes-tigridis,
ALYSICARPUS	7	A.bupleurifolius, A.hamosus, A.longifolius, A.monilifer, A.rugosus, A.tetragonolobus, A.vaginalis
CASSIA	8	C.absus, C.fistula, C.mimosoides, C.obtusifolia, C.occidentalis, C.pumila, C.sophera, C.tora
ERAGROSTIS	8	E.ciliaris, E.diarrhena, E.pilosa, E.poaeoides, E.tenella, E.tremula, E.unioloides, E.viscosa
INDIGOFERA	8	I.cassioides, I.cordifolia, I.hirsuta, I.linifolia, I.linnaei, I.oblongifolia, I.tinctoria, I.trita
CYPERUS	10	C.alopecuroides, C.brevifolius, C.bulbosus, C.compressus, C.corymbosus, C.iria, C.kyllingia, C.niveus, C.rotundus, C.tricaps

TABLE - 3.7.(c) DOMINANT FAMILIES OF THE FOREST VEGETATION STUDIED.

S.No.	NAME OF THE FAMILY	NUMBER OF	
		GENERA	SPECIES
1.	Fabaceae	41	86
2.	Poaceae	55	75
3.	Asteraceae	35	40
4.	Cyperaceae	7	21
5.	Euphorbiaceae	9	19
6.	Malvaceae	9	17
7.	Acanthaceae	12	16
8.	Amaranthaceae	9	14
9.	Tiliaceae	3	14
10.	Scrophulariaceae	8	10

TABLE - 3.7(d) DOMINANT FAMILIES OF THE PRESENT STUDY AS COMPARED WITH THE UPPER GANGETIC PLAINS AND THE BRITISH INDIA.*

JHANSI FOREST PRESENT WORK	UPPER GANGETIC PLAINS After Hooker f., 1904	BRITISH INDIA After Hooker f., 1904
Fabaceae	Poaceae	Orchidaceae
Poaceae	Fabaceae	Fabaceae
Asteraceae	Cyperaceae	Poaceae
Cyperaceae	Asteraceae	Rubiaceae
Euphorbiaceae	Scrophulariaceae	Euphorbiaceae
Malvaceae	Malvaceae	Acanthaceae
Acanthaceae	Acanthaceae	Asteraceae
Amaranthaceae	Euphorbiaceae	Cyperaceae
Tiliaceae	Convolvulaceae	Lamiaceae
Scrophulariaceae	Lamiaceae	Urticaceae

* After Hooker f., 1904; Courtesy of Imperial Gazett. India.

Liliaceae (14 spe.) > Scrophulariaceae (10 spe.) etc.. (Table - 3.7c). These dominant families of the study sites were compared with the flora of the Upper Gangetic Plains and the British India in Table - 3.7(d).

3.6 H A B I T A T M O D I F I C A T I O N S

As already mentioned in the contents of section 1.9; Chapter - 1, and also referred by Agarwal and Mathur[8], that the A.pendula is morphologically very uniform species, but during extensive surveys of the local forest blocks the author noticed breaks in the pattern of variation and recognised two different kinds of A.pendula. There were prominent morphological variations with differences in the appearance of 'Kardhai' especially in the size and the erectness of the species[370].

One of the most striking variation noticed was that countless individuals of 'Kardhai' were greatly reduced in their size (Plate - 13). Due to reduction they all became moss-like in appearance i.e., almost prostrate in habit (Plate - 14). These forms were usually spiny and were profusely branched in a zig-zag manner. Branches were horizontally spreading and covering a large circumference some times upto 2 - 3 metere in diameter above the ground.

PLATE - 13. NOT A MOSS, BUT MOSS - LIKE CARPET OF ANOGEISSUS PENDULA SPREADING OVER THE GROUND : A TYPICAL CASE OF PHENOTYPIC PLASTICITY.

PLATE - 14. TRUNKLESS, ZIG - ZAGLY BRANCHED AND UMBONALLY SHAPED ANOGEISSUS PENDULA, : AN ADDITIONAL INSTANCE OF ITS PLASTIC RESPONSE.

Main trunk was always found lacking in such individuals and the whole structure generally occuping a height of 30 - 60 cm in umbonal shape. One may definitely get surprised in identifying them as A.pendula. For the sake of convenience, hereafter, these prostrate forms may be known as variation no. 1 or Var.-1.

Another distinct variation recorded was that the innumerable individuals of A.pendula were bushy or shrubby in their appearance and were prominantly armed with spines on their main trunk as well as on their branches (Plate - 15). These thorn like spines were of the following dimensions : Length : 10 - 50 mm; diameter at base : 5 - 10 mm with pointed apex. It was interesting to note that most of the spines were containing leaves on their base and or on their apex. For the sake of convenience, hereafter, these bushy and armed forms may be known as variation no. 2 or Var.-2.

3.7 I N T E R P R E T A T I O N S

JHANSI, for reasons of inaccessibility, has remained mainly unexplored. The district, having now become very important, particularly with the coming up of the University of Bundelkhand, the teacher, scholars and the

PLATE - 15. THE BUSHY AND PROMINENTLY ARMED APPEARANCE OF ANOGEISSUS PENDULA. A DEFENSIVE ADAPTATION IN RESPONSE TO SOME PARTICULAR NEED : ANOTHER SYMBOLIC EXAMPLE OF THIS HABITAT MODIFICATIONS.



students feel handicapped for want of proper knowledge of the botanical wealth of this area. Hence an attempt has been made to ecologically enumerate the floristics of the region.

Understanding of an ecological system needs exploration of the structural and functional behavior of the its constituent components. Analysis of the quantitative and qualitative structure and composition of community enables us to understand in a better way and to predict hopefully the effect of man and other animal's impact on it.

The vegetation of the forest viz., Bangawa, Chandpura, Laxmanpura, Simravari and Nayakhera seems to be heterogeneous in their composition. Even the tree crops standing in the same locality were not homogeneous in their quality, density, structure and floristics. Micro-climatic differences produced due to variation in the aspect of slopes, and proximity to water sources caused a very perceptible variation in the vegetation. Thus, over an area with uniform climate, micro-climatic conditions affect upon the vegetation resulting in segregation of species to form distinct stands. Main factors governing the distribution of forest types and stand variations are geological formations and the resultant soils, physiography of the tract and the biotic influences.

The distribution of individual tree species within the community is affected by a number of factors[139, 183]. Either modifying the environment in a favourable way or by direct impact over other species one species have a beneficial effect over other. Or else the species are having a differential tolerance capacity to a varying environmental conditions and thus show association variation[311].

The variation in tree vegetation in relation to sites may be attributed to the different intensity of exposures to the grazing, browsing and lopping. The trees designing the top emergent layer were stunted in growth may be due to poor soil, rocky substratum, lack of soil moisture and scorching heat and thus they hardly attain a height of 10 m or more in general.

The soil of the forest is poor, and moisture conditions are inadequate. The slopes are generally steep and hence well drained. This combined with high temperature tends to create dryness. Such soil supports the elements enumerated in the present study.

The differences in density and the quality of trees in these sites may be credited to the heavy biotic influence and comparatively dry habitats as well as the differences in the soil quality. The community co-efficient

of these forests show that the degree of differentiation in these forests are greater. It may be due to the differences in climatic, edaphic and topograhic variations as well as the micro-climatic conditions. The dimensions that a tree may attain depend not only on the origin of the seed but also on inter and intra-specific competitions, soil and the climatic conditions as well under which it happens to grow and develope.

A.pendula has withstood the onslaughts of man more successfully than the other species because of the ability to grow on extremely degraded land. On newly eroded area or on steep slopes with topographically immature soils or in forests which have been heavily felled and or burnt, the dominant forest tree in the region is nearly always A.pendula. It usually forms extensive pure forest and is also mixed with other species. The common associates appear to be Acacia catechu, Acacia nilotica, Bauhinia racemosa, Butea monosperma and Holoptelia integrifolia. There were associations with other species as well viz., Acacia leucophloea, Diospyros melanoxylon , Lannea coromandelica, Sterculia urens and Wrightia tinctoria but such associations were less frequent.

In contrast to the woody component, the herb layer of the Kardhai forest was the most diverse among the forests of the region. It is clear from the data that the herb layer in these forests were distinct. Factor responsible for this seems to be light and the moisture. Light controls in a numerous ways the growth of plants. Where the top layer has very few trees, the ground layer recieves sunshine almost unintercepted. Consequently, the herbs develops covering most of that ground. Where the top has large number of trees and the light available to ground is almost checked or too less, the herb therefore, are scantily developed there.

In the months of July, August, and September though the temperatures are high there is a good deal of humidity present in the atmosphere, due to the rains. Whereas, during the rest of the year, the precipitation is very less or say almost nil and the evaporation from the soil surface appears to become high over most of the area. Under thick and closed canopies, temperatures are usually low than in the open and the humidity remains somewhat high, whereas, in the openings the temperatures are generally high than in the closed canopies and the humidity also remains relatively low. The rate of evaporation will also

vary in these two extremities. The ratio of precipitation/ Evaporation determine the trend on the development of the soil and ultimately the composition of the vegetation[323].

Differences in the floristic compositions are also apparently influenced by the rainfall patterns. It is the distribution rather than the total amount of rainfall that is of importance in determining development of the soils and the vegetation in that area.

The reaction of species on the environment is one of the outstanding features of succession. In addition to the external environmental factors which regulate the overall composition of the vegetation, there exists a series of intrinsic factors which continue to induce vegetational change[183]. In the adjustment to the modified environment, the entire composition and structure of the vegetation may be altered[482].

The presence of species like Aristida adscensionis, Eragrostis ciliaris, Heteropogon contortus, Imperata cylindrica, Melanocenchris jacquemontii, Perotis indica, Pumalia lappacea, Peristrophe bicalyculata, Solanum surattense, Trichodesma amplexicaule, Volutarella divaricata, Xanthium strumarium etc., may perhaps be ascribed to the low

rainfall and overgrazing. whereas, in other locations, presence of perennial grass like Bothriochloa pertusa, Cynodon dactylon, Dichanthium annulatum, Iseilema laxum, Sehima nervosum, etc., indicates well developed soils and the better rainfall conditions. These grass also have a high fodder value and there presence represents the sub-climax stage in plant succession.

Due to high intensity of grazing and the high degree of erosions in some parts of these forests, the communities of annual desert grass were predominant. On the other hand presence of Cassia tora, Lantana camara, Parthenium hysterophorus, etc., in some locations perhaps did not permit the growth of herbaceous vegetation and they also prevented the regeneration of tree species.

The most of these small local communities were at a low seral stage of succession and were unable to progress further because of the continuous operations of illicit felling, illegal grazing and the incidental fires.

However, the picture is not completely faded. The presence of some species having good fodder value is perhaps the brighter aspect of these communities. These nutritive herbaceous species were viz., Alhagi camelorum,

Alysicarpus spe., Bothriochloa pertusa, Commelina benghalensis, Dinebra retroflexa, Eremopogon foveolatus, Indigofera spe., Rhynchosia minima, Salsola baryosma, Sehima nervosum etc.

Several exotic species were found in the forest. Some weeds which are natives of tropical south America, north America, Tropical Africa, Pantropical, Eurasian, Mediterranean, Afro-asian countries were found to become naturalized in the region. These exotic weeds were viz., Acanthospermum hispidum, Argemone mexicana, Arundo donax, Cichorium intybus, Crotalaria medicaginea, Jatropha gossypifolia, Lantana camara, Malvastrum coromandelianum, Opuntia elatior, Parthenium hysterophorus, Physalis minima, Scoparia dulcis, Xanthium strumarium etc., etc.

Weeds are one of the major biological agents affecting the productivity of forest crops. They not only compete with the forest vegetation for nutrition but impede wild life management programmes as well. Species like Abutilon indicum, Biden pilosa, Blepharis molluginifolia, Cleome viscosa, Datura stramonium, Echinops echinatus, Gomphrena spe., Hyptis suaveolens, Peristrophe bicalyculata, Pupalia lappacea, Xanthium strumarium etc., are found in places where human interferences on the vegetation were more.

Ground vegetation is very sensitive to changes in sites within a short spell of time and space as compared to the tree vegetation. cela va sans dire that the vegetation at a particular site is the result of the interaction of various climatic and bio-edaphic factors. Initially many species compete with each other to establish their hold on the vacant site. After a great deal of struggle, competition and the adjustments, only a few are able to sustain themselves. Incidentally some becomes dominant and occupies the upper social status, whereas, others remain on the lower level of their convivial dignity. The preponderance of the particular species in a vegetation complex also indicates its aggressiveness and adaptability on a particular site within a given set of climatic and bio-edaphic conditions.

The predominance of annual weeds and short lived unpalatable perennials indicate severe over-grazing and it also characterizes the vegetation in its advanced stages of depletion. The unpalatable species avoided by the grazing animals multiplies and increases numerally in the absence of competition due to the decrease in the population of the palatable species.

Since the vegetation of the area is controlled much more by the local conditions than the general climate, it will include species that can live only under the existing circumstances.

The herbaceous monsoonic flora of these forests are rich and interesting. With the commencement of the rains, ground is covered by several flowering plants. If the moisture is sufficient, a rich cover of herbs will develope that will last in the dry months of February and March. But if the soil is poor, dry and neglected, the area is generally invaded by prickly vegetation.

A community has a characteristic structural composition of life-forms *viz*., trees, shrubs, herbs, grass epiphytes, thallophytes *etc*. Study of community from the view point of life-form can help in an understanding of functions of individual organisms in it. Raunkiaer gave a classification of life-forms which is based upon the overwintering parts or the location of organs that survive summer drought or other unfavourable environmental conditions that determines the life form and also the position and degree of protection to perennating buds. Raunkiaer based this series on the assumption that the original environment was considerably

more moist and uniformly hot than it is now, and accordingly the most primitive life-form is that which dominates tropical vegetation at the present time. Conversely the more highly evolved species are found in the colder area of the world[183].

All the species of plants in a community can be classified into life-forms and their ratio expressed in numbers or percentages form a floristic 'Biological-spectrum' Every regional spectrum contains atleast one class of life-form whose percentage remain substantially higher than that of the other classes. This dominant class is taken as an indicator of the climate and environments of that region. Thus, the life-forms are believed to be correlated with the climate and their relative proportion in a community indicate the climatic zone of the place ut infra :

Phanerophytes	: Warm and moist (Tropics),
Chamaephytes	: Extremely cold climate (Arctic and Alpine),
Hemicryptophytes	: Conditions suitable for grass-lands (Temperate regions)
Geophytes	: Warm and dry, and
Therophytes	: Hot and dry (Deserts).

Thus, geographically widely separated communities can be very usefully compared with one another on the basis of their biological spectrum (Table - 3.8).

The present study reveals a therophytic plant climate as therophytes were best adapted to the general climate of the area and so far were most abundant. Thus, the spectrum constructed on the basis of current study indicate hot and dry climate of the region. This may be attributed to the recurring fires, relative xeriemss of the habitat, broken canopy enabling annuals to grow during rainy season, and the heavy grazing. The higher number of therophytes undoubtedly represent strong periodic climate and biotic influences.

The onset of monsoon brings about the germination of Therophytes. The plants of this class exhibit rapid growth, development, flowering and fruiting. Therophytes, such as Aristida adscensionis, Cassia obtusifolia, Cassia tora, Cleome viscosa, Corchorus aestuans, Crotalaria medicaginea, Dactyloctenium aegyptium, Digitaria adscendens, Eragrostis ciliaris, Leucas aspera, Tephrosia strigosa, Triumfetta rhomboidea etc., grow during rainy season and dies in winter. Whereas, Acanthospermum hispidum, Achyranthes

TABLE - 3.8 THE PERCENTAGE REPRESENTATION OF DIFFERENT LIFE - FORMS IN THE FLORA OF VARIOUS GEOGRAPHICAL AREA OF THE WORLD IN GENERAL AND INDIA IN PARTICULAR.

GEOGRAPHICAL AREA	AUTHORITY*	PERCENTAGE DISTRIBUTION OF THE SPS. AMONG THE LIFE - FORMS					ZONATION OF THE VEGETATION	PROBABLE CLIMATE
		Ph	Ch	He	Ge	Th		
World's Normal	I	46	9	26	6	13	Ph	Moist
Alps, above 3600 m	I	-	67	33	-	-	Ch	Cold
Denmark	I	7	3	50	22	18	He	Cold
Ellesmere land, Tundra	I	-	23.5	65.5	11	-	He	Cold
Libyan Desert	I	12	21	20	5	42	Th	Dry
Paris	D	8	6.5	51.5	25	9	He	Cold
Switzerland	D	-	24.5	68	4	3.5	He	Cold
Sub-tropical evergreen India	C	63	17	2	5	13	Ph	Moist
Mahabaleshwar	C	60	19.6	3.4	3.8	13.2	Ph	Moist
Matheran	C	65.3	17.2	2.2	4.8	10.5	Ph	Moist
Allahabad	J	38	9.2	3.4	7.8	41.6	Th - Ph	Warm & Moist
Rajasthan Desert	E	14.3	18.9	15.5	3.4	47.9	Th	Dry & Warm
Northern semi-arid zone, India	G	23.3	18.3	10.4	8.2	39.8	Th	Dry & Warm
Southern semi-arid zone, India	G	30.3	13.4	11.0	10	35.3	Th - Ph	Warm & Moist
North Kanara	A	48.3	14.8	4	10.9	22	Ph	Moist
Karamnasa, Watershed	H	40	6	1	10	43	Th - Ph	Warm & Moist
Poona	B	22	38	4	3	33	Ch - Th	Warm & Moist
Andhra	G	51	12	4	4	29	Ph	Moist
Open grasslands, Jhansi	F	12.3	11.4	2.6	26.3	47.4	Th - Ge	Warm & Moist
Forest area, Jhansi Present work executed		20.1	25	6.5	7.2	41.2	Th	Dry & Warm

* After : A = Arora, 1966, courtesy of Indian For.,[24]; B = Bharucha and Dave, 1944, courtesy of J. Univ. Bombay,[50]; C = Bharucha and Ferreira, 1941, courtesy of J. Indian Bot. Soc.,[51]; D = Braun - Blanquet, 1932, courtesy of McGraw Hill,N.Y.,[66]; E = Das and Swarup, 1951, courtesy of Univ. Rajputana, Studies Biol.Sci.,[102]; F = Kanodia, 1981, courtesy of Ph.D. Thesis, Jiwaji Univ. Gwalior,[175]; G = Meher-homji 1964, courtesy of J. Indian Bot. Soc.,[235]; H = Rao, 1968, courtesy of Recent Adv. Trop. Ecol.,[337]; I = Raunkiaer, 1934, courtesy of Clarendon Press, Oxford,[340]; J = Srivastava, 1944, courtesy of J. In Bot. Soc.,[426].

LEGENDS : Ph = Phanerophy(tes/tic), Ch = Chamaephy(tes/tic), He = Hemicryptophy(tes/tic), Ge = Geophy(tes/tic), Th = Therophy(tes/tic).

aspera, Ageratum conyzoides, Argemone mexicana, Biophytum sensitivum, Emicostema hyssopifolia, Hickxia ramosissimum, Rumex dentatus, Sclerocarpus africana, Spilanthus acmella, Volutarella divaricata etc., grow during winter and nearly dies in summer. Plants like Abelmoschus manihot, Barleria prionitis, Bidens pinnata, Datura stromonium, Echinops echinatus, Indigofera tinctoria, Peristrophe bicalyculata, Pupalia lappacea, Xanthium strumarium etc., may survive even in the dry periods and may continue in the following rainy season.

It has been found mathematically that if in a community the species are spread over a large number of genera, the generic diversity is high and low if only a few genera are represented. Thus the generic diversity varies with generic coefficient which can be determined by the following formula :

$$\text{Generic co-efficient} = \frac{\text{Total number of Genera}}{\text{Total number of Species}} \times 100$$

It was interesting to note the proportion of species, genera and the families belonging to the monocots and the dicots. The ratio of species belonging to monocots

and dicots was 1 : 3.83 ; of genera - 1 : 4.01 ; and of families - 1 : 16 . In the whole of India, the proportion of genera to species is 1 : 7, in the Gangetic plains it is 1 : 2.2 whilst in the present study it is only 1 : 1.52. This show the small proportion of species to the number of genera in the area. It also confirms to the general rule that within the same floral region, the smaller the flora, the smaller the genus species ratio.

Variation is the law of nature. Variation occur among individuals of the same species and form the basis of selection. These are also noticed in forest trees. Any feature of an organism or its parts which is of definite value in allowing that organism to exist under the conditions of its habitat may be called an 'ADAPTATION'. Most adaptation are now believed to arise by the selective action of environment operating as a sieve on genetic variations, the origin of which are strictly matters of chance.

Adaptation at first appears to be a process constantly conferring benifits on organisms. However, in the long term it is frequently disastrous as proved repeatedly by the paleontologic record[104].

Phenotypic plasticity is the ability of an individual organism to alter its physiology and morphology in relation to changes in the environmental conditions. This ability is particularly important in plants, whose sessile life-style requires them to deal with ambient conditions[372]. The notion that plants respond morphologically to changes in their environment has a long tradition. The nature and extent of phenotypic responses to varied environments has been firmly documented[43, 88, 461].

A plant may respond to the environment simply by altering its growth rate without affecting the allocation of resources or plant morphology. Alternately, developmental patterns may be altered, resulting in marked changes in morphology or allocation[258, 423, 485]. It has been shown that plasticity is a property of specific traits in response to particular environments[43].

The ecological importance of phenotypic plasticity lies in the fact that it has a bearing on the range of habitats a species can occupy, since it tends to make the individuals adaptable to more than one habitat.

It appears that in the past as at present, the *Araucaria pendula* tree was subjected to heavy exploitation

so much so that the tree is now reduced to a prostrate, scrubby-shrub spreading on rocks and giving an entirely different appearance from that of the normal plants of A.pendula. Normally, the 'Kardhai' is a medium sized, gregarious and deciduous tree having nearly straight and clear boles generally of 75 - 100 cm or rarely of more gbh. This slow growing indigenous tree species usually possess armless, smooth and drooping branches.

It appears that these variations viz., Kar-1 and Kar-2 arose as an adaptation in response to a particular need or the utility and were certainly associated with some ecological factors. It was noticed that where there was tremendous pressure of grazing and browsing, A.pendula appeared as Kar.-1 i.e., very much reduced in its height, spreading all along the ground and appearing like a green carpet during and after rains. Almost the same type of appearance of Kardhai were also noticed in Sheopur forest division of Madhya Pradesh[462].

Sheep and goats were quite fond of nibbling the tender leaves from the leading shoots. Constant browsing very often is found to result in the tips assuming a thorny appearance probably a device for protection against the struggle for exixtence. Such observations were also recorded in Narsingpur block of

Sheopur forest division of Madhya Pradesh[49].

It was also noticed that where there were excessive, indiscriminate and illegal cutting of the forest trees particularly 'Kardhai' by the local villagers, A.pendula appeared as Kar.-2.

It is interpreted that the variations in form of Kar.-1 and Kar.-2 are purposive. Such phenotypic plasticity is interesting in itself, strictly as a developmental phenomenon and clearly focuses interest on the utility of the platic response as an adaptive tool[296]. This is definitely a new find and a matter of pleasant surprise for those who have not come across such mystics of Nature.

Populations of plants are subject to attack at all stages of their life cycles. Intensive herbivory may lead directly to the local extinction of a plant species, or may weaken plants and make them more vulnerable to subsequent pressures. Defence against herbivory may be secured by many different mechanisms that may depend upon the texture and the composition of the plant species. One of such defences is the presence of anatomical structures i.e., thorns[210].

It is not, however, a question of simple discontinuity in particular features of the Kardhai plants but also the fact that the discontinuously varying characters are highly significantly correlated. As per Champion and Seth's system of classification[77], these very much reduced forms (fig.-1) are the last stage of degradation before it is totally eliminated. If these biotic influences continues there is real danger of the extermination of this native species of Anogeissus pendula.

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C H A P T E R – IV

PHYSICAL CHARACTERISTICS OF SEEDS

C H A P T E R - IV

P H Y S I C A L C H A R A C T E R I S T I C S O F S E E D

4.1 P R E M I S E

DIRECTLY or indirectly, seeds are the source of life sustaining nutrients for man and other animals. Symbolically, they represent renewal and illustrate the tenacity of life in the face of a hostile world. After dispersal throughout the myriad terrestrial and the aquatic environment, the dormant seed remain poised to sprout or to germinate at the first signal from the environment of better times for the perpetuation of life[234].

Seed has been defined variously. Some of the interesting definitions are ut infra :

* "Seed is the greatest miracle ever created by Nature."
  - ANONYMOUS.

* "Flowering plant unit of reproduction capable of developing into another such plant."
  - OXFORD DICTIONARY.

* "The seed is an excellent method for multiplication and distribution of the species."
  - L.V.BARTON[44].

* "Containing the new plant in miniature, equipped with structural and physiological devices to fit in for its role as a dispersal unit, the seed is well provided with reserve food which sustains the young plant until a self sufficient autotrophic organism can be established."
-J.D.BEWLEY AND M.BLACK[48].

* "Seed is the principal means for perpetuation of most trees and many woody species from one generation to the next."
- S.L.KRUGMAN, M.I.STEIN AND D.M.SCHMITT[200].

* "The seed is a convenient unit in which to suspend growth, as it is so easily transported and dispersed."
- A.C.LEOPOLD AND P.E.KRIEDEMANN[209].

* "Seed is a highly organised packet of energy that provides for the complete development of the primary plant body, the emergent seedling."
- W.T.McDONOUGH[234].

* "Seed is the important stage of a plant and its characteristics depicts the sum total effects of various stresses and strains, which the

species has been subjected to during its evolution, in its specific habitat of origin."
- M.G.NIKOLAEVA[281].

* "Seed is the reproductive germs of flowering plants."
- H.WEBBLEY[434].

Not much is known about the physiology of seeds in the state of suspended growth except that they become partly dehydrated and the respiration falls to a very low level[209]. Morphological and the physical studies of seed are of much value. These studies include seed size, seed weight, conditions of seeds, water holding capacity, composition of inert matter etc.

Gola Ya Sans die that in Anogeissus pendula, the seeding regeneration is not adequate and dependable. The germination capacity is low despite huge production of seeds[49, 225, 226, 227, 456], and the seedlings have also the tendency to die-back with a high percentage of mortality[453]. Natural regeneration by seedlings seems to be poor because of the conditions unsuitable for their establishment. Hence, an attempt has been made to estimate and to enhance the germinability of 'Kardhai' seeds without actual germination. Such studies are especially helpful for the tree seeds[156], with respect to value of the seed for planting. It is also one of the important aspects of silviculture.

The separation of undesirable material, i.e., inert matter, from the desirable material is essential in order to obtain improved germination and to maintain the genetic purity. Since germination tests are based on pure seed component, it can be readily seen that purity analysis and the germination test complement each other. Thus, the actual planting value of seed can be determined only when the purity analysis and germination test are considered together.

4.2 R E V I E W O F L I T E R A T U R E

The practical handling of tree seeds and the concomitant physiological aspects have been discussed at length in several books[21, 40, 197], while general seed physiology of herbaceous and woody species are reviewed in other publications [45, 92, 93]. Specific topics on seed physiology and morphology are treated in some of the articles[26, 62, 115, 193, 444]. Articles on seed testing have also been published in some comprehensive reviews[112, 140, 171, 216].

Seed polymorphism has been reported in many plants particularly in leguminous herbs and tree species[303, 304, 349, 391, 498]; Extensive research on the effects of seed size and weight on the rate of germination and various aspects of plant growth has been carried out[131, 145, 151, 199, 399, 439, 494]. Size of the seed in many conifers has been found to have a controlling influence on their

germination and or on the initial growth of their resulting seedlings[40, 86, 174]. The size and shape of the seed depends on the structure which the plant is growing during the period of its seed production[231]. Larger seeds are usually heavier because the size of the seed in case is a function of the endosperm quantity contained inside the seeds. Therefore, fast germination of the seed, or fast growth of the seedling in the initial phase may be a reflection of the amount of endosperm - energy or endosperm - nutrient - pool[174, 305]. small size seeds with low seed weight may be helpful in better dispersal, but are disadvantageous as far as the quantity and the quality of its reserve food material is concerned[26].

Seed weight is affected by size, moisture content and the proportion of filled seeds in the lot[40, 62, 171]. The size usually reflects the comparative nutrient pool and the energy of a seed. Secondly, the quality of seed to be sown per unit area or per nursery bed is fixed by the weight. Hence, smaller seeds usually result in a high density of seedlings per unit area as against a low density by sowing large sized seeds of similar sample weight in the area. Sowing of mixed or ungraded seed of a species gives rise to an uneven density of stocking in a nursery bed, which in turn develops heterogeneity in vigour and the size of the seedlings.

For testing seed quality, there are the methods of estimating seed germinability with or without actual germination. In many tree species, seeds often germinate slowly and unevenly, therefore, methods not involing actual germination have been especially helpful for testing the viability of the tree seeds[156].

The cutting test is the simplest of all the viability tests. Earliest attempts to get a rapid estimation of the germination capacity of seed was through the cutting test. The seeds were simply cut opened and the number of empty ones were recorded. This gives a fairly accurate measure of germination expectancy when the seeds are fresh or of high quality[473], but permits no evaluation of deterioration in the embryo[44].

Biochemical and physiological tests have the merit of being able not only to determine the viability of deeply dormant seeds, but also to estimate the germination conditions within much shorter periods[156]. Biochemical staining tests have shown that the viable seeds are visibly stained, whereas, the non-viable seeds are not.

The biochemical method was first established with tellurium salts[155] and selenium salts[110]. Later on the value of tetrazolium salt was recognized as an excellent indicator of reduction in biological materials[201]. Since then, the use of 2, 3, 5 - Triphenyl tetrazolium chloride (TTC) as an useful viability indicator has been reported by several

workers[300, 303].

Tetrazolium salts are more stable than some of the dyes (Indigo-carmine, Bismark-brown, Methyl-blue, Malachite-green etc.) and can work even under aerobic conditions. In addition to imparting permanent colour, the tetrazolium salt has a low toxicity both for the plants and for the experimenter as well, and is one of the few organic compounds that can remain visibly coloured in their reduced state[44]. In the presence of viable tissue, the almost colourless tetrazolium salt is transformed by enzymes into the insoluble bright red triphenyl formazan. A description of the general technique of tetrazolium testing has been provided by Moore and Smith[297].

The viability test is effectively a death test. However, it is widely accepted that loss of viability is almost the last stage of deterioration, the final catastrophe[160] which is preceded by more subtle changes.

4.3 M A T E R I A L A N D M E T H O D

THE use of seed of an appropriate class and from an approved source is necessary for raising a crop. The seed used for raising seedling should be of known purity, appropriate class and invariable obtained from potentially healthy stocks. With these objectives in mind, various physical characteristics of A.pendula seeds were determined and judged by the relative

percentage of various parameters with respect to six different sites.

Seeds for morphology, germination and the growth studies were collected from the third girth class (50 - 75 cm gbh) of Anogeissus pendula trees directly from the branches through hand-jerk as recommended[456]. The collections were made in six different local forest blocks viz., Bangawa, Chandpura, Laxmanpura, Simravari, Nayakhera and Jharar, hereafter, known as S-I, S-II, S-III, S-IV, S-V and S-VI respectively. Ten individuals of parent tree in each of the six blocks were selected for making collection of their seeds in order to obtain a composit sample of different seed types. The seeds were collected in the month of February and March 1986. Following studies were performed on the structure and the composition of Kardhai seeds :

(a). Seed and non-seed component,
(b). Seed weight,
(c). Seed size,
(d). Moisture content,
(e). Water holding capacity, and
(f). Viability.

4.3(a) S E E D & N O N - S E E D C O M P O N E N T

From the composit samples of seeds, collected from ten individual trees in each of the six forest sites, the seed and non-seed components were physically separated.

5 replicates of 5 g each from each of the six sites were used. The following seed and the non-seed components were sev red from all the replicates (5 X 6 sites = 30) for making sub-samples of the each category ut infra :

I. SEED COMPONENT :

(A). Pieces of broken seeds,

(B). Insect damaged seeds,

(C). Abnormally shaped seeds,

(D). Shriveled and cracked seeds, and

(E). Normal and pure seeds.

II. NON-SEED COMPONENT :

(A). Inflorescence axis,

(B). Branches, twigs, barks etc.,

(C). Dry and fresh leaves,

(D). Insect galls, and

(E). Seed or seed-like structures of other species.

After separation each of these sub-samples of different categories were weighed individually. For weighing the seed samples and the various seed components, a monopan electric balance was used.

4.3(b) S E E D W E I G H T

100 seeds from each of the six seed sources were weighed individually i.e., single seed at a time, on a monopan

electric balance and their weights were recorded. Similarly, 5 replicates of 1 g each of the six localities were used for counting the number of seeds in them. Their volumes were also determined by making use of a calibrated cylinder.

4.3(c) S E E D S I Z E

100 seeds from each of the six blocks were used for determining their average size. Each seed of these lots was measured individually for determining its length, breadth and the thickness with the help of a vernier scale. Size-index, shape-index and the cubic area of each seed was calculated through these measurements.

4.3(d) M O I S T U R E C O N T E N T

Freshly collected seed-lots from all the six sites, consisting of 5 replicates of 5 g each (W_1) were oven dried at 70°C temperature till constant weight and their dry weights recorded (W_2) using physical balance. The decrease in the weight was determined ($W_1 - W_2$) and the moisture contents of each of the replicates was analysed on percentage basis as follows :

$$\text{Percentage moisture} = \frac{W_1 - W_2}{W_1} \times 100$$

4.3(e) W A T E R H O L D I N G C A P A C I T Y

5 replicates of 5 g each from each of the six different seed sources were weighed (W_1) immediately after their collection. Each of the seed replicates was then soaked in distilled water (250 ml per 100 seeds)[22] at room temperature

(16.8°C ± 1.0°) till the increase in weight due to imbition became constant. The weight of these fully swollen and saturated seeds were determined (W_2) after blotting their surface dry. Lastly, the swollen and turgid seed samples were placed in an oven for air drying them at 70°C temperature till constant weight. The dried seed samples were at once transferred into the desiccators and were allowed to cool. After cooling, the dry weight of each sample was determined (W_3).

Percentage of imbibed water, relative turgidity and the saturation deficit was calculated for each of the samples as follows :

$$\% \text{ of imbibed water} = \frac{\text{Increased weight}}{\text{Initial weight}} \times 100$$

$$= \frac{W_2 - W_1}{W_1} \times 100$$

$$\text{Relative turgidity} = \frac{\text{Fresh weight - dry weight}}{\text{Saturated weight - dry weight}} \times 100$$

$$= \frac{W_1 - W_3}{W_2 - W_3} \times 100$$

$$\text{Saturation deficit} = \frac{\text{Saturated weight - Fresh Wt.}}{\text{Saturated weight - dry Wt.}} \times 100$$

$$= \frac{W_2 - W_1}{W_2 - W_3} \times 100$$

OR Saturation deficit = 100 - Relative turgidity

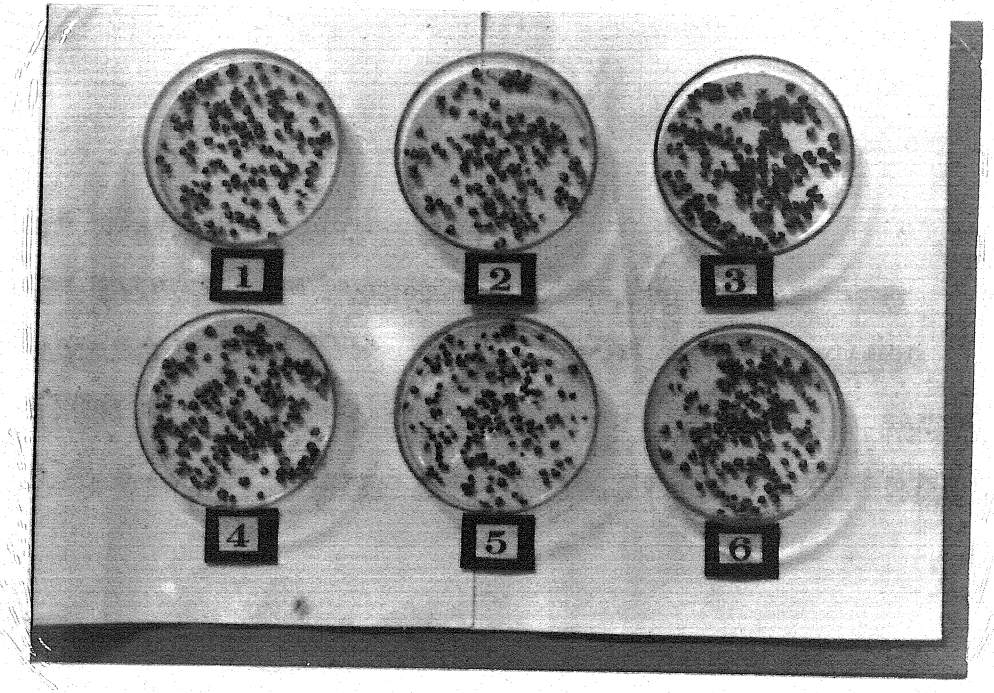
4.3(f) V I A B I L I T Y

One thousand seeds of six sites each were soaked in distilled water (250 ml per 100 seeds)[22] continuously for 24 hours. These soaked seeds were divided into two groups of 500 seeds each. For rapid estimation of viability, the seeds of the first group (100 seeds X 5 replicates) were subjected to a cutting test, whereas, the seeds of the second group (100 seeds X 5 replicates) were biochemically stained.

For cutting test, the soaked seeds were simply cut opened with a nut-cracker and the numbers of empty (non-viable) and filled (viable) seeds were recorded. For biochemical staining, the seeds were cut obliquely into two equal parts passing through the centre of the embryo. These cut see s were completely immersed in the petri-dishes containing freshly prepared 0.1% solution of 2, 3, 5 - Triphenyl tetrazolium chloride. The petri-dishes were placed in dark for about an hour. The s eds were then observed for red colouration (liliac). These liliac/carmine coloured portions of the seeds were *in esse* the stained embryos and only the viable seeds show this colouration. The number of coloured (viable) and uncoloured (non-viable)seeds were recorded. The percentage viability of seeds was calculated *ut infra* :

$$\% \text{ Viability} = \frac{\text{Total number of viable seeds}}{\text{Total number of seeds examined}} \times 100$$

PLATE - 16. SEED POLYMORPHISM IN *ANOGEISSUS PENDULA* WITH RESPECT TO THE SITES OF THEIR COLLECTIONS *Viz*., 1. BANGANA, 2. CHANDPURA, 3. JHARAR, 4. LAXMANPURA, 5. SIMRAVANI AND 6. MAYAKHERA FORESTS.


1
2
3
4
5
6

4.4 O B S E R V A T I O N S

PHYSICAL characteristics of *A.pendula* seeds, as measured in relation to six different sites, are presented in tabulated forms. Table 4.1(a), 4.1(b) and 4.1(c) offers an idea of what proportion of the working sample is of pure seed and what proportion is made up of other material. Each category is expressed as a percentage by weight of the seed or non-seed component, as the case may be, and also of the original working sample.

Table 4.1(a) indicates that the seed samples collected from Chandpura forest contained highest proportion of the seed component followed by the representative sample of Naya-Khera block with 88.09 and 75.72 percent compositions respectively. On the other hand, seeds collected from Simravari forest contained highest allocation of non-seed component *i.e.*, of inert matter, which was 50.25%. The samples belonging to the Jharar block were *proxima accessit* with 40.38% composition of inert matter. (Fig. - 4.1).

Table 4.1(b) displays composition of various categories of seed-component as percentage by their weights. The table expresses that Chandpura samples contained highest proportion of pure seeds not only in the seed-component, but in the composit lots as well. Composition of pure seeds was 87.20% when determined in the seed-component, otherwise, it was 76.82% in the working sample as a whole. Composition of

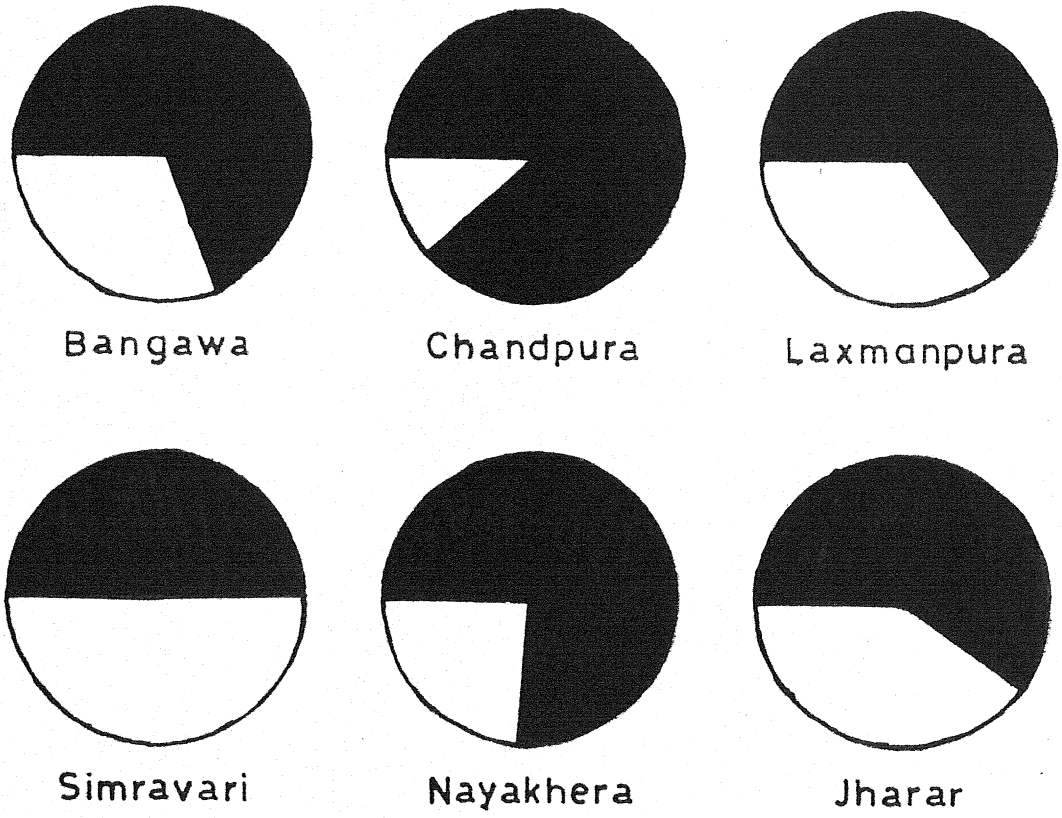


FIG. 4.1 PERCENTAGE COMPOSITION OF SEED AND NON-SEED(INERT) COMPONENTS IN SEED LOTS OF A. PENDULA IN RELATION TO SIX DIFFERENT FOREST SITES. THE AREA OF THE CIRCLE IS EQUAL TO CENT-PERCENT AND THE AREA OF THE INNER BLACK PART IS PROPORTIONAL TO THE PERCENTAGE OF THE SEED COMPONENT.

TABLE - 4.1.(a) PERCENTAGE COMPOSITION OF SEED AND NON-SEED COMPONENTS IN THE SEED LOTS* OF *ANOGEISSUS PENDULA* IN RELATION TO SITES.

COMPONENTS		LOCALITIES					
		S - I	S - II	S - III	S - IV	S - V	S - VI
SEED :	Av.	69.00	88.09	64.73	49.75	75.72	59.62
	S.E. ±	4.98	± 3.36	± 4.56	± 2.62	± 3.78	± 3.26
	Max.	75.54	95.94	70.15	52.61	81.57	65.56
	Min.	61.92	68.63	58.06	41.17	67.32	55.56
NON-SEED :	Av.	31.00	11.91	35.27	50.25	24.28	40.38
	S.E.	± 4.98	± 3.36	± 4.56	± 2.62	± 3.78	± 3.26
	Max.	38.08	31.37	41.94	58.83	32.68	44.44
	Min.	24.46	4.06	29.85	47.39	18.43	34.44

* 5 Replicates of 5 g each

LEGENDS : Localities : S - I : Rangawa, S - II : Chandpura,
S - III : Laxmanpura, S - IV : Simravari,
S - V : Mayakhera, S - VI : Jharar

Calculation Heads : Av. : Average, S.E. : Standard error,
Max. : Maximum, Min. : Minimum

TABLE - 4.1.(b) PERCENTAGE COMPOSITION OF VARIOUS CONSTITUENTS IN THE SEED - COMPONENT* OF ANOGEISSUS PENDULA IN RELATION TO SITES.

CONSTITUENTS		SITES					
		BANGAVA	CHANDPURA	LAXMANPURA	SIMRAVARI	NAYAKHERA	JHARAR
A. :	Av.	9.46	8.23	9.32	15.61	9.44	9.20
	S.E.	± 0.98	± 1.06	± 0.76	± 2.14	± 1.32	± 1.44
	Max.	13.50	14.40	13.21	24.46	13.56	12.94
	Min.	7.51	3.92	7.29	9.30	5.63	6.53
	P.	6.53	7.25	6.03	7.76	7.15	5.49
B. :	Av.	5.70	2.41	4.63	6.46	7.12	9.48
	S.E.	± 0.88	± 0.76	± 0.64	± 0.68	± 0.96	± 0.76
	Max.	7.17	3.65	6.23	10.11	8.51	11.58
	Min.	4.68	1.49	3.63	4.27	5.66	7.80
	P.	3.93	2.13	3.00	3.22	5.39	5.65
C. :	Av.	0.39	0.29	0.61	1.58	0.20	0.18
	S.E.	± 0.24	± 0.12	± 0.34	± 0.70	± 0.09	± 0.07
	Max.	0.57	0.46	0.74	2.13	0.28	0.26
	Min.	0.29	0.18	0.43	1.08	0.14	0.12
	P.	0.27	0.25	0.39	0.78	0.15	0.11
D. :	Av.	1.78	1.87	1.80	1.27	0.91	0.85
	S.E.	± 0.38	± 0.44	± 0.56	± 0.48	± 0.32	± 0.40
	Max.	2.20	2.47	2.24	1.58	1.08	1.20
	Min.	1.05	1.67	1.20	1.05	0.71	0.62
	P.	1.23	1.64	1.17	0.63	0.69	0.50
E. :	Av.	82.67	87.20	83.64	75.08	82.33	80.29
	S.E.	± 7.52	± 5.46	± 9.12	± 4.38	± 4.92	± 8.74
	Max.	85.49	91.48	86.57	82.70	86.60	84.85
	Min.	77.25	80.07	79.12	64.64	76.81	75.39
	P.	57.05	76.82	54.14	37.35	62.35	47.87

* Excluding inert matter

LEGENDS : Constituents : A. = Pieces of broken seeds, B. = Insect damaged seeds, C. = Abnormally shaped seeds, D. = Shriveled and cracked seeds, E. = Pure seeds
Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum, P. = Percentage composition in a seed-lot including inert matter.

pure seeds in test samples of various sites were in the following descending order : Chandpura (76.82%)>Nayakhera (62.55 %)>Bangawa (57.05%)>Laxmanpura (54.14%)>Jharar (47.37%)>Simravari (37.35%).

Second largest share in the seed component of the test samples was of the pieces of broken and naturally damaged seeds half or less the original size. The category of seed component was in the following decreasing proportion by percentage of the weight of the sampling lot : Simravari (07.76%) > Chandpura (07.25%) > Nayakhera (07.15%) > Bangawa (06.53%) > Laxmanpura (006.03%) > Jharar (05.49%).

Other categories of the seed component were viz., externally insect damaged seeds; abnormally shaped seeds and the immature, shriveled or cracked seeds. The average percentage composition of these categories in various representative samples were in the following step-down sequences :

Externally insect damaged seeds : Jharar (05.65%) > Nayakhera (05.39%) > Bangawa (03.93%) > Simravari (03.22%) > Laxmanpura (03.00%) > Chandpura (02.13%).

Abnormally shaped seeds : Simravari (00.78%) > Laxmanpura (00.39%) > Bangawa (00.27%) > Chandpura (00.25%) > Nayakhera (00.15%) > Jharar (00.11%).

immature, shriveled or cracked seeds : Chandpura (01.64%) > Bangawa (01.49%) > Laxmanpura (01.17%) > Mayakhera (00.69%) > Simravari (00.63%) > Jharar (00.50%).

Table 4.1(e) fixes proportion of various constituents of the non-seed component (inert matter) in the seed lots of A.pendula collected from six different sites. These constituents were viz., pieces of inflorescence axis, flower etc.; pieces of branches, twigs, barks, soil particles, broken and unattached seed wings etc.; pieces of leaves both fresh and dry or semi-dry; insect galls; and the seeds or seed-like structure of other species.

The major share in the non-seed component was of the pieces of branches, twigs etc. This was followed by the second largest contribution made by the pieces of inflorescence axis. Other categories of the inert matter varied in their proportions with respect to their sites. The percentage composition (in non-seed component) of the pieces of branches etc., was 76.51%, 72.16%, 67.98%, 64.68%, 56.30% and 33.98% in Bangawa, Jharar, Laxmanpura, Simravari, Chandpura and Mayakhera forests respectively. However, the average percentage composition of this category in the working samples as a whole, was in the following descending order : Simravari (32.50%) > Jharar (29.14%) > Laxmanpura

TABLE - 4.1.(c). PERCENTAGE COMPOSITION OF VARIOUS CONSTITUENTS IN THE NON-SEED COMPONENT OF ANOGRISSUS PENDULA IN RELATION TO SITES.

CONSTITUENTS		SITES					
		BANGAWA	CHANDPURA	LAXMANPURA	SIMRAVARI	NAYAKHERA	JHARAR
A.	Av.	15.28	24.92	18.17	18.50	52.83	20.03
	S.E.	± 2.04	± 2.66	± 0.94	± 1.44	± 3.28	± 1.86
	Max.	25.94	37.70	20.09	21.75	62.64	24.41
	Min.	5.32	15.56	14.60	16.20	37.54	16.02
	P.	4.74	2.97	6.41	9.30	12.82	8.09
B.	Av.	76.51	56.30	67.98	64.68	33.98	72.16
	S.E.	± 4.02	± 3.70	± 1.64	± 2.38	± 1.22	± 2.82
	Max.	86.83	73.20	71.44	67.77	43.32	76.95
	Min.	65.10	30.81	62.27	61.78	28.77	67.72
	P.	23.72	6.70	23.98	32.50	8.25	29.14
C.	Av.	4.36	9.14	3.53	6.18	5.37	2.62
	S.E.	± 0.58	± 1.48	± 0.76	± 0.32	± 0.94	± 0.86
	Max.	5.64	23.92	5.31	6.83	7.62	3.68
	Min.	3.19	5.10	2.61	5.32	3.56	1.93
	P.	1.35	1.09	1.24	3.11	1.30	1.06
D.	Av.	2.03	3.66	5.25	10.29	6.47	2.49
	S.E.	± 0.74	± 1.84	± 1.22	± 1.86	± 0.84	± 0.24
	Max.	3.89	10.08	7.86	12.06	8.94	2.96
	Min.	0.00	0.00	3.78	8.51	4.39	2.17
	P.	0.63	0.44	1.85	5.17	1.57	1.00
E.	Av.	1.82	5.98	5.07	0.35	1.35	2.70
	S.E.	± 0.14	± 0.78	± 0.44	± 0.06	± 0.38	± 0.54
	Max.	3.24	10.33	6.16	0.47	2.58	4.02
	Min.	0.72	3.54	3.79	0.26	0.64	1.42
	P.	0.56	0.71	1.79	0.18	0.33	1.09

LEGENDS : Constituents :- A = Inflorescence axis, B = Branch twigs and bark etc.,
C = Leaves, D = Insect balls, E = Seeds or seed-like structures of other species.
Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum,
P. = Percentage composition including the seed components.

(23.98%) > Bangawa (23.72%) > Mayakhera (08.25%) > Chandpura (06.70%).

Interestingly enough, though the composition of the pieces of inflorescence axis in the non-seed component of Chandpura samples seemed to be second in the decreasing sequence with 24.92% share, even then, it was lowest in the sequence when considered in the test samples as a whole with only 02.97% of contribution.

Donations made by other categories of the non-seed component in the representative samples were in the following diminishing ranks :

Pieces of leaves : Simravari > Bangawa > Mayakhera > Laxmanpura > Chandpura > Jharar.

Pieces of insect-galls : Simravari > Laxmanpura > Mayakhera > Jharar > Bangawa > Chandpura.

Seed like structures of other species : Chandpura > Laxmanpura > Jharar > Bangawa > Mayakhera > Simravari.

The percentage composition by weight of various constituents in the seed and the non-seed components of A.pendula seed-samples in relation to their sites are depicted with the help of a mountainograph in Fig.-4.2

Table 4.2 specifies that the working samples of Laxmanpura contained relatively lesser number of seeds

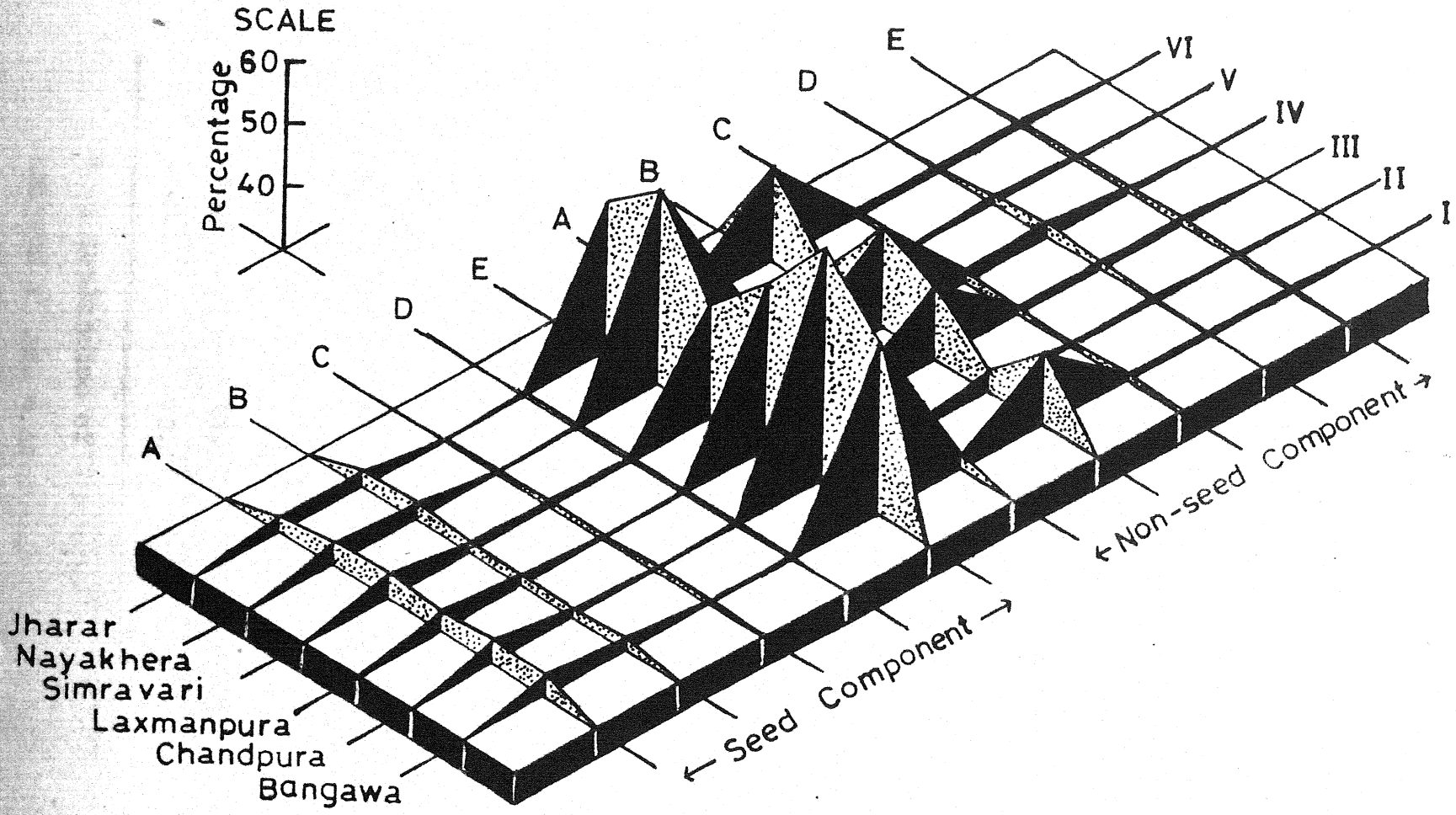


FIG. 4.2 MOUNTAINOGRAPH REPRESENTING PERCENTAGE COMPOSITION BY WEIGHT OF VARIOUS CONSTITUENTS IN SEED AND NON-SEED COMPONENTS OF A. PENDULA SEED-LOTS IN RELATION TO SITES.

TABLE - 4.2 NUMBER AND VOLUME PER GRAM SEED SAMPLES*, VOLUME/NUMBER RATIO, AND WEIGHT OF A SINGLE SEED** OF ANOGEISSUS PENDULA FROM DIFFERENT HABITATS.

PARAMETERS	HABITATS					
	BANGAWA	CHANDPURA	LAXMANPURA	SIMRAVARI	NAYAKHERA	JHARAR
NUMBER :						
Av.	158.6	139.8	116.8	264.6	149.2	130.8
S.E.	± 5.06	± 3.64	± 4.32	± 3.98	± 7.56	± 5.44
Max.	167.00	146.00	122.00	271.00	164.00	138.00
Min.	150.00	134.00	107.00	258.00	124.00	122.00
VOLUME (cc) :						
Av.	28.8	34.42	27.68	17.50	26.24	19.00
S.E.	± 3.88	± 4.60	± 3.74	± 2.66	± 3.92	± 2.18
Max.	57.2	73.8	62.5	37.1	58.2	32.3
Min.	8.00	4.5	6.2	3.2	6.7	9.0
V/N RATIO :						
Av.	0.18	0.24	0.23	0.06	0.17	0.14
S.E.	± 0.03	± 0.03	± 0.04	± 0.02	± 0.03	± 0.02
Max.	0.38	0.55	0.58	0.14	0.46	0.26
Min.	0.04	0.03	0.05	0.01	0.04	0.06
WEIGHT (mg) :						
Av.	5.4	7.0	8.2	3.4	6.2	7.4
S.E.	± 0.30	± 0.54	± 0.76	± 0.14	± 0.68	± 0.42
Max.	11.8	15.2	17.2	6.4	14.8	15.6
Min.	2.0	1.2	1.8	1.0	1.6	2.2

* 5 Replicates of 1 g each ** Average of 100 seeds

LEGENDS : Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

per gram of composition, whereas, seed-lots belonging to Simravari forest contained relatively higher number of seeds per gram of sample. The number of seeds in a gram lot ranged from minimum 107 (Laxmanpura) to maximum 271 (Simravari).

Weight of a single seed varied from minimum 1 mg to maximum 17.2 mg in the representative samples of Simravari and Laxmanpura respectively. On an average, the seeds of Laxmanpura sites were comparatively heaviest (8.4 mg/seed) than the seeds belonging to the Simravari sites, which were relatively lightest (3.8 mg/seed). Thus, the array of the sites were in the following descending succession with respect to the average number of seeds per gram of their samples : Simravari (264.6) > Bangawa (158.6) > Nayakhera (149.2) > Chandpura (139.8) > Jharar (130.8) > Laxmanpura (116.8). This sequence of the sites was in the reverse order with regard to the average weight of a single seed and thus, it can be written as : Laxmanpura (8.2 mg/seed) > Jharar (7.4 mg/seed) > Chandpura (7.0 mg/seed)> Nayakhera (6.2 mg/seed) > Bangawa (5.4 mg/seed) > Simravari (3.4 mg/seed).

Regarding volume, the V/N ratio indicates that the seeds belonging to Chandpura block were relatively much spacious and that they occupied the largest space of 0.24 cc

per seed. However, the seeds gathered from Simravari occupied a relatively very less space of 0.06 cc per seed. The number and the volume per gram seed samples of A.pendula from six different habitats has been illustrated with the help of a hexagonal star in Fig.-4.3a. Similarly, average weight of a single seed is also explained diagrammatically in Fig. 4.3b.

Table 4.3 serves to inform the physical dimensions i.e., length (L), breadth (B) and the thickness (T) of A.pendula seeds. On the basis of these three measurements, size-index (LxB), shape-index (L/B) and the cubic area (LxBxT) of the seed were calculated. Values inscribed in the column of size-index indicates that the size of 'Kardhai' seeds rocked from minimum 7.00 mm^2 (Simravari) to maximum 61.06 mm^2 (Bangawa). On an average the seeds of Chandpura were the largest (41.48 mm^2) and was closely followed by that of Laxmanpura (40.09 mm^2) and Bangawa (39.11 mm^2) belongings. On the other hand, the average size of seeds gathered from Simravari block was the lowest (16.29 mm^2).

The L/B ratio states that the seed of Kardhai might be slightly square shaped as the minimum values of shape-index ranged in between 1.03 (Laxmanpura) to 1.12 (Simravari) i.e., nearly unity. They might be rectangular as well, as the maximum values varied from 1.28 (Dharar) to

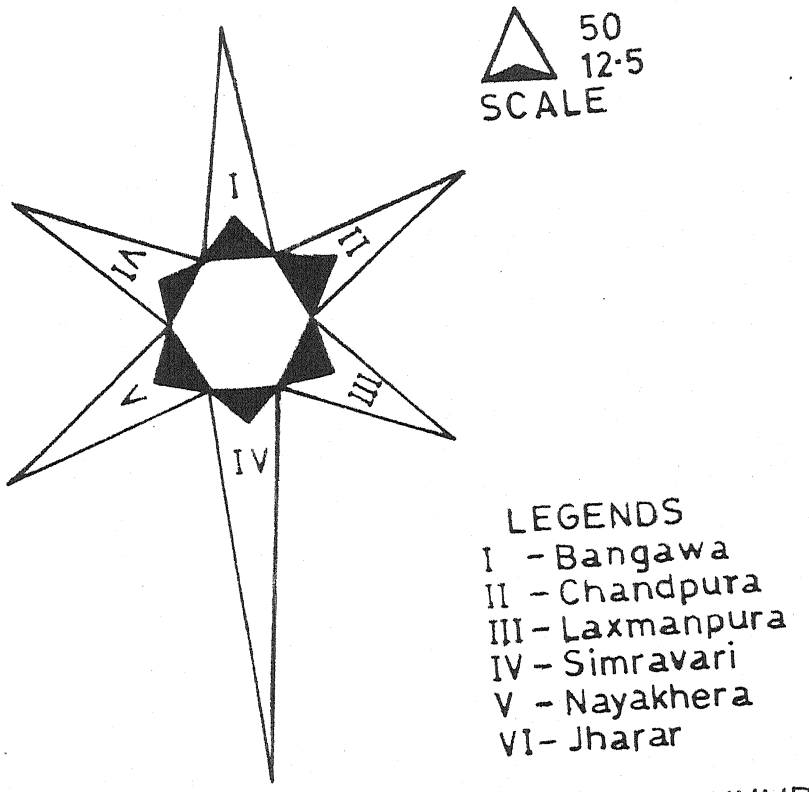


FIG. 4.3A - HEXAGONAL STAR REPRESENTING NUMBER AND VOLUME PER GRAM SEED SAMPLES OF A.PENDULA. BASAL BLACK PART OF EACH RAY IS PROPORTIONAL TO THE AVERAGE VOLUME (ml) OF CONCERNED SEED-LOT. AREA OF TRIANGULAR RAYS ARE PROPORTIONAL TO THE AVERAGE NUMBER OF SEEDS PER GRAM SAMPLE.

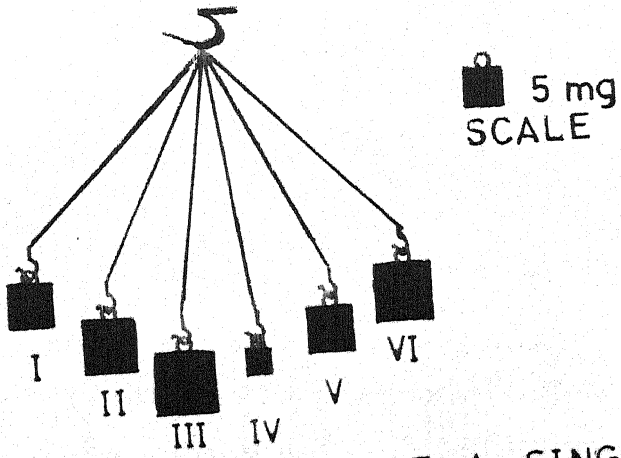


FIG. 4.3B - AVERAGE WEIGHT OF A SINGLE SEED OF A.PENDULA FROM SIX HABITATS. LENGTH OF EACH BLACK SQUARES ARE PROPORTIONAL TO THE AVERAGE WEIGHT OF CONCERNED SEED.

TABLE - 4.3 SHAPE AND SIZE INDEX, AND AREA OF THE ABOGEISSUS PENDULA SEEDS* IN R
TO VARIOUS SITES.

PARAMETERS	SITES				
	BANGAWA	CHANDPURA	LAXMANPURA	SIMRAVARI	NAYAKHERA
LENGTH (mm) :					
Av.	6.96	7.08	6.86	4.66	6.10
S.E.	± 0.24	± 0.36	± 0.14	± 0.32	± 0.26
Max.	8.6	8.4	8.2	6.4	7.4
Min.	5.6	4.8	5.3	2.8	3.5
BREADTH (mm) :					
Av.	5.42	5.68	5.66	3.28	4.64
S.E.	± 0.38	± 0.28	± 0.34	± 0.18	± 0.40
Max.	7.2	7.1	7.2	4.8	6.4
Min.	3.5	3.8	3.1	2.3	2.9
SIZE-INDEX (mm^2) :					
Av.	39.11	41.48	40.09	16.29	29.75
S.E.	± 3.64	± 3.04	± 3.18	± 1.96	± 3.02
Max.	61.06	55.38	53.28	28.32	45.44
Min.	21.70	18.24	16.43	7.00	10.15
SHAPE-INDEX :					
Av.	1.34	1.25	1.26	1.42	1.33
S.E.	± 0.04	± 0.02	± 0.02	± 0.03	± 0.03
Max.	1.77	1.44	1.71	1.78	1.53
Min.	1.06	1.10	1.03	1.12	1.11
THICKNESS (mm) :					
Av.	1.64	2.06	1.84	1.06	1.74
S.E.	± 0.18	± 0.20	± 0.20	± 0.08	± 0.12
Max.	1.9	2.5	2.4	1.5	2.1
Min.	0.8	1.2	1.0	0.7	1.0
AREA (mm^3) :					
Av.	65.97	89.01	75.82	19.02	52.50
S.E.	± 4.16	± 7.38	± 5.66	± 2.04	± 4.52
Max.	103.97	138.45	110.04	42.48	95.42
Min.	26.04	32.83	19.72	5.60	17.26

* Average of 100 seeds

LEGENDS : Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

1.78 (Simravari) i.e., more than unity. However, the average values signify that the general shape of A.pendula seeds were rectangular and the dimension of length was always more than the dimension of breadth. The seed length vibrated from minimum 2.8 mm (Simravari) to maximum 8.6 mm (Bangawa). Similarly, breadth of the seed also oscillated to and fro 2.3 mm (Simravari) and 7.2 mm (Both Bangawa and Laxmanpura).

The thickness of seeds varied from minimum 0.7 mm (Simravari) to maximum 2.5 mm (Chandpura) with the average thickness of 2.06 mm, 1.38 mm, 1.84 mm, 1.74 mm, 1.64 mm and 1.06 mm in the seed samples obtained from Chandpura, Jharar, Laxmanpura, Nayakhera, Bangawa and Simravari blocks respectively.

The cubic area of A.pendula seeds swunged in between 5.60 mm^3 (Simravari) and 138.45 mm^3 (Chandpura). The average values of cubic area rambled from minimum 19.02 mm^3/Simravari to maximum 89.01 mm^3/Chandpura through 52.40 mm^3/Jharar, 52.50 mm^3/Nayakhera, 65.97 mm^3/ Bangawa and 75.82 mm^3/Laxmanpura.

A diagrammatic representation of length, breadth and the thickness of A.pendula seeds in relation to six forest blocks is provided in Fig. -4.4(a); The shape and the size-index are illustrated in Fig. -4.4(b) and the cubic area of the seed is drawn in Fig. -4.4(c).

Table 4.4 provides clues in understanding the amount of moisture present in A.pendula seeds in relation to their sites. The percentage values are sandwitched in

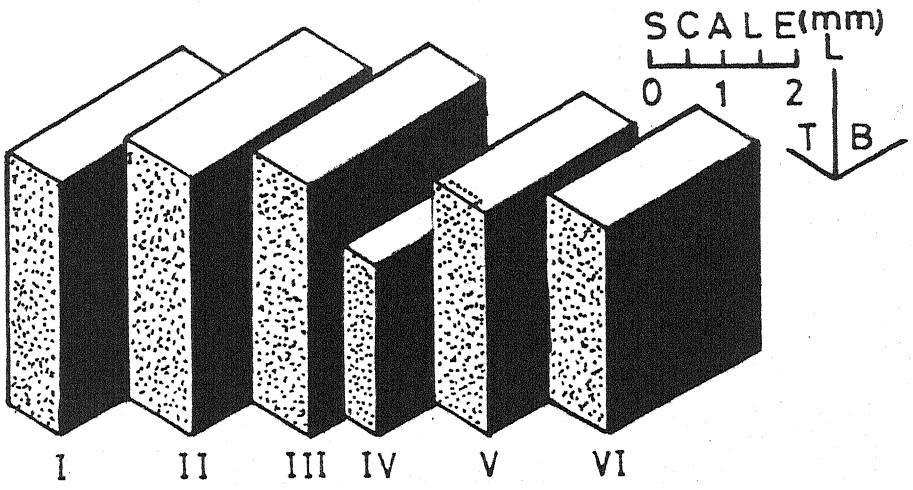


FIG. 4.4A-THREE DIMENSIONAL REPRESENTATION OF LENGTH (L), BREADTH (B), AND THE THICKNESS (T) OF A. PENDULA SEED IN RELATION TO SITES.

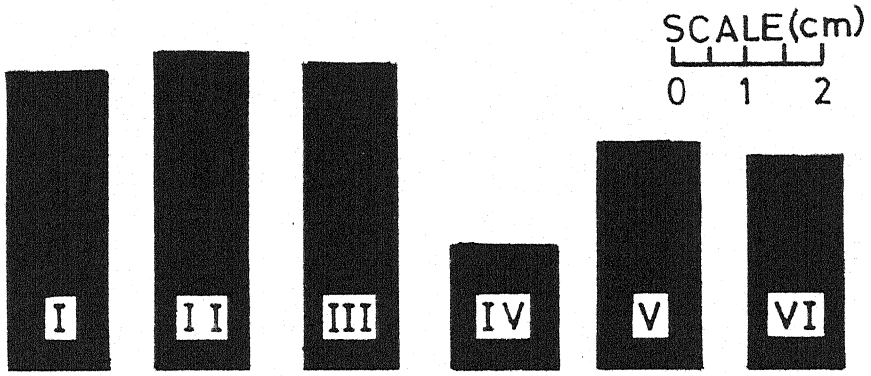


FIG. 4.4B - SIZE AND THE SHAPE INDEX OF 'KARDHAI' SEEDS IN RELATION TO SITES. LENGTH (mm) OF THE HISTOGRAM IS PROPORTIONAL TO THE SIZE INDEX, WHEREAS, THE BREADTH (cm) IS TO SHAPE INDEX.

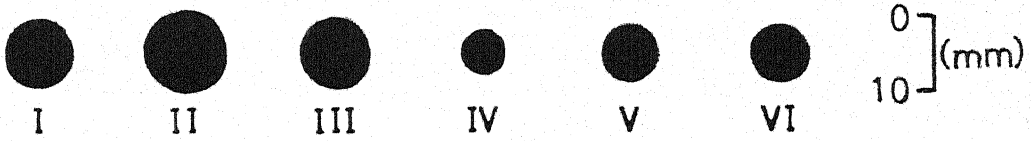


FIG. 4.4C - AREA OF A. PENDULA SEEDS IN RELATION TO SITES. AREA OF THE CIRCLE IS PROPORTIONAL TO THE AVERAGE AREA OF SEEDS.

TABLE - 4.4 PERCENTAGE OF MOISTURE PRESENT IN THE AIR-DRIED FENUGREEK SEEDS* OF DIFFERENT LOCALITIES.

CALCULATION HEADS	L O C A L I T I E S					
	S - I	S - II	S - III	S - IV	S - V	S - VI
Av.	14.40	11.52	14.33	16.76	11.31	12.22
S.E.	± 1.26	± 0.98	± 1.44	± 1.96	± 1.44	± 1.18
Max.	16.75	12.77	17.29	18.88	12.01	13.03
Min.	12.65	8.99	12.42	13.33	10.63	11.40

* 5 Replicates of 5 g each

LEGENDS : Localities : S-I : Bangawa, S-II : Chandpura,
S-III : Laxmanpura, S-IV : Simravari,
S-V : Nayakhera, S-VI : Jharar,
Calculation Heads : Av. : Average, S.E. : Standard error,
Max. : Maximum, Min. : Minimum

between the maximum 10.88% (Simravari) and the minimum 8.99% (Chandpura) of moisture contents. The seeds belonging to Nayakhera and Chandpura blocks were comparatively drier with only 11.31% and 11.52% of average moisture as compared with the seeds of Simravari (16.76%). Water contents in the seeds belonging to Jharar, Laxmanpura and Bangawa localities were 12.22%, 14.33% and 13.40% respectively.

Table 4.5 inscribes water holding capacity of A.pendula seeds in relation to the sites of their collection. Imbibition, relative turgidity and the saturation deficit are expressed as percentage by weight of the original working samples. Percentage values of imbibition roamed from minimum 78.34 (Simravari) to maximum 152.56 (Chandpura). The average values of imbibed water in the seeds of different sites were in the following ascending manner : 85.90%/Simravari < 89.54%/Bangawa < 98.16%/Laxmanpura < 103.84%/Jhara < 118.10%/Nayakhera < 124.92%/Chandpura. It can be noted from the data that the seeds obtained from Chandpura, Nayakhera and Jharar blocks imbibed more than their original weight, whereas, the seeds of Laxmanpura, Bangawa and Simravari blocks imbibed less than their initial weight.

The said table 4.5 also discloss the facts that the seeds acquired from Simravari were relatively most turgid, whereas, the seeds inhereted at Chandpura were relatively least turgid with 16.74% and 10.92% of relative

TABLE - 4.5 WATER HOLDING CAPACITY OF ANOGEISSUS PENDULA SEEDS* IN RELATION TO SITES OF THEIR COLLECTIONS.

PARAMETERS	SITES					
	BANGAWA	CHANDPURA	LAXMANPURA	SIMRAVARI	NAYAKHERA	JHARAR
IMBIBITION PERCENTAGE :						
Av.	89.54	124.92	98.16	85.90	118.10	103.84
S.E.	± 3.86	± 6.44	± 6.02	± 4.76	± 6.84	± 4.32
Max.	98.62	152.56	115.42	92.46	142.72	119.98
Min.	81.06	100.18	84.58	78.34	96.86	90.26
RELATIVE TURGIDITY :						
Av.	14.24	10.92	13.62	16.74	11.52	11.96
S.E.	± 0.96	± 0.74	± 0.92	± 1.12	± 0.88	± 1.02
Max.	19.60	14.78	18.84	22.36	14.78	13.84
Min.	10.82	7.90	9.58	11.24	8.64	9.18
SATURATION DEFICIT :						
Av.	85.76	89.08	86.38	83.26	88.48	88.04
S.E.	± 2.22	± 1.88	± 2.04	± 2.58	± 1.70	± 1.52
Max.	89.18	92.10	90.42	88.76	91.36	90.82
Min.	80.40	85.22	81.16	77.64	85.22	84.16

* 5 Replicates of 5 g each.

LEGENDS : Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum.

turgidity respectively. Reverse was the case with Saturation deficit, since both, saturation deficit and the relative turgidity are inversely related. Hence, saturation deficit was highest in the seeds heaped in Chandpura, whereas, it was lowest in the seeds linked with Simravari block with 89.08% and 83.26% respectively. Water holding capacity of A.pendula seeds in relation to their sites are elucidated in Fig. 4.5(a).

Ad finem, the Table 4.6 documents the estimation of percent viability by cutting and the biochemical staining of A.pendula seeds with respect to their sites. Results of the cutting test corresponds with the results of the biochemical staining. Seeds related to Chandpura block were most viable exhibiting 10.2% and 18.6% viability in cutting and the biochemical staining respectively. On the other hand, seeds connected with Simravari block were highly non-viable displaying only 6.8% and 9.6% viability in cutting and the staining tests respectively. Any way, the viability percentage wandered from minimum 4% (Simravari) to maximum 13% (Chandpura) in cutting test and from minimum 5% (Simravari) to maximum 21% (Chandpura and Mayakhema) in tetrazolium staining. Rapid estimates of percent viability by cutting and the biochemical staining of 'Kardhai' seeds in relation to their sites are provided in Fig.-4.5(b).

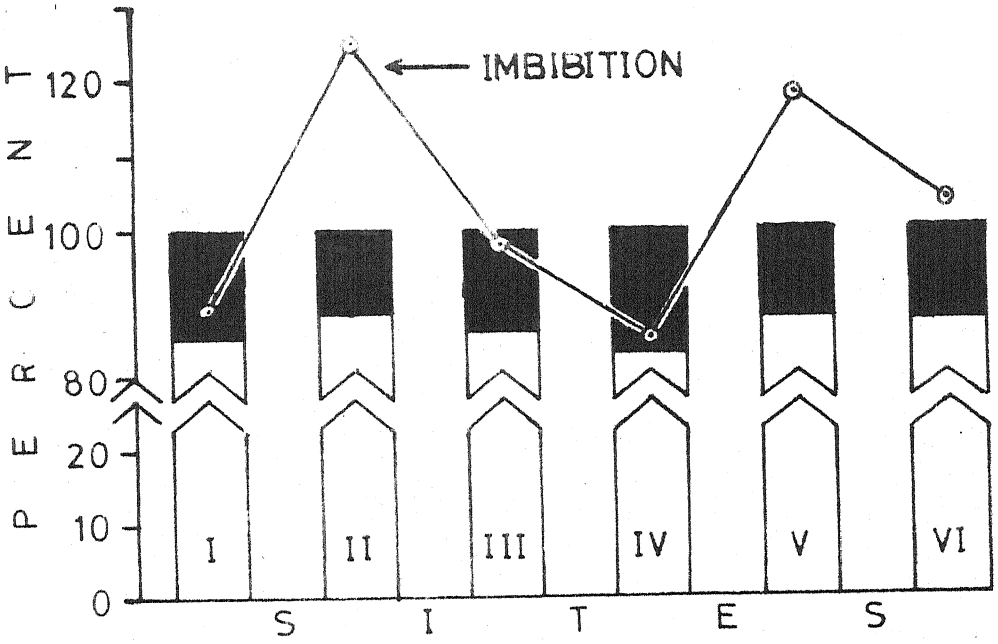


FIG. 4.5A WATER HOLDING CAPACITY OF A. PENDULA SEEDS IN RELATION TO SITES. BLACK PART OF THE HISTOGRAM IS PROPORTIONAL TO THE RELATIVE TURGIDITY, WHEREAS, REMAINING IS EQUIVALENT TO THE SATURATION DEFICIT.

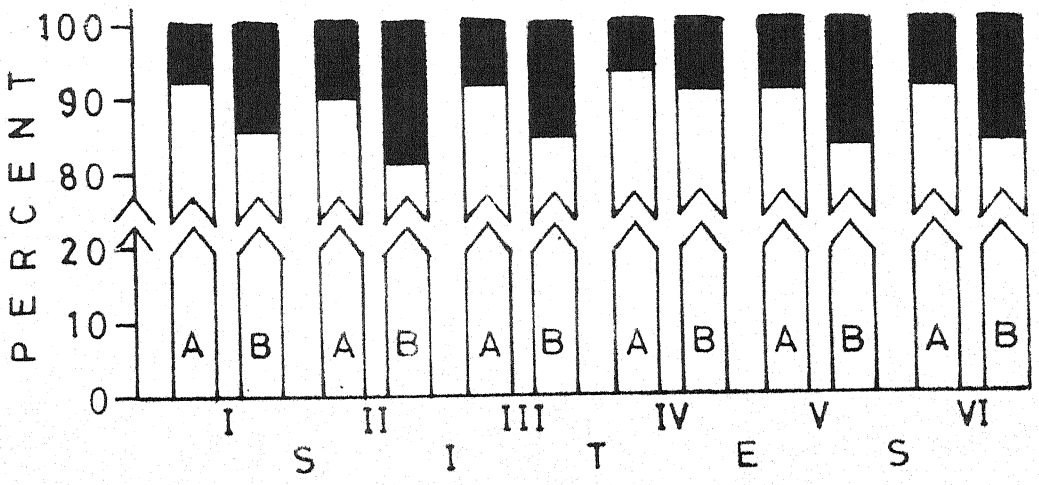


FIG. 4.5B RAPID ESTIMATE OF VIABILITY PERCENTAGE BY CUTTING (A) AND BIOCHEMICAL STAINING (B) OF A. PENDULA SEEDS IN RELATION TO SITES. BLACK PART OF THE HISTOGRAM IS PROPORTIONAL TO THE VIABLE SEEDS, OTHERWISE TO THE NON-VIABLE SEEDS.

TABLE - 4.6 RAPID ESTIMATES OF VIABILITY PERCENTAGE BY CUTTING AND THE BIOCHEMICAL STAINING OF *ANOGEISSUS PENDULA* SEEDS* IN RELATION TO THEIR SITES OF COLLECTIONS.

VIABILITY TESTS		SITES					
		BANGAWA	CHANDPURA	LAXMANPURA	SIMRAVARI	NAYAKHERA	JHARAR
CUTTING TEST :							
A. :	Av.	7.8	10.2	8.2	6.8	9.6	8.8
	S.E.	± 0.36	± 1.22	± 0.78	± 0.72	± 1.02	± 0.54
	Max.	11.0	13.0	11.0	9.0	12.0	11.0
	Min.	5.0	8.0	5.0	4.0	7.0	6.0
B. :	Av.	92.2	89.8	91.6	93.2	90.4	91.2
	S.E.	± 4.36	± 3.98	± 3.56	± 5.02	± 4.86	± 4.14
	Max.	95.0	92.0	95.0	96.0	93.0	94.0
	Min.	89.0	87.0	89.0	91.0	88.0	89.0
TETRAZOLIUM TEST :							
A. :	Av.	14.6	18.6	15.4	9.6	16.6	16.2
	S.E.	± 1.32	± 1.54	± 0.98	± 0.68	± 1.28	± 1.14
	Max.	17.0	21.0	19.0	14.0	21.0	12.0
	Min.	10.0	13.0	12.0	5.0	12.0	12.0
B. :	Av.	85.4	81.4	84.6	90.4	83.4	83.8
	S.E.	± 3.68	± 3.02	± 2.88	± 3.56	± 2.98	± 2.76
	Max.	90.0	87.0	88.0	94.0	88.0	88.0
	Min.	83.0	77.0	81.0	86.0	79.0	80.0

* 5 Replicates of 100 seeds each

LEGENDS : A. = Viable seeds, B. = Non viable seeds,

Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

4.5 I N T E R P R E T A T I O N S

IN seed testing, physical and the biological characteristics of a seed-lot are measured to assess the value of the lot. These tests help in fixing the quality and other characteristics of the commodity[62]. In addition to germination test, certain physical characteristics of a seed-lot can be described or even measured that are of great value to the seedsman or the nursery man.

The purity test is usually the first test to be performed and it provides pure seeds for other tests. As regards interpretation of the results of purity test, it can be said that variations in the percentage composition of seed components in the seed-lots in relation to their sight might be due to the variations in the micro-environments and the prevailing biotic factors in that area. As rests, the following reasons may also be held responsible for the decrease in the purity of the seed-lot : (a)- velocity of wind in the area, (b) shape of the groun, (c) - density of the trees and (d) - influence of fauna particularly rodents, birds etc. It also seems that the compound impact of these and whatsoever other factors might be more accountable in increasing the impurity of the seed-lots.

Interestingly, the mathematically derived heterogenity value indicates that the variation in percentage composition of the seed component was homogenous since the

values of heterogenity arrived in negative i.e., -0.517 by making use of the following formulae[12] ;

$$H = \frac{V}{W} - 1$$

where, H = Heterogenity value,

V = Actual variance found among the samples in respect of the attribute tested, and

W = Expected (theoritical) variance of samples in respect of the attribute tested.

Any way, considering each site as a replicate, the average composition of pure seeds in seed-lots of A.pendula must be near about 55.93% ± (S.E.) 5.4536 and the composition of seed components : 67.82% ± (S.E) 5.4098 by weight.

Inconsistencies in the number of seeds per gram lot in relation to their sites were certainly due to strife in the weight of individual seed. The results obtained so far also confirms the argument (Table 4.2). Naturally, the more the weight of an individual seed, the less will be the number of the seeds per unit weight of sample. Hence, the seed numericals in a sample are in some reflections of their individual weights. Thus, it can be said genuinely that the seed numerals directly depend upon the factors answerable for

increase or decrease in their weight.

Disagreements in weight and in size of 'Kardhai' seeds could be credited to the result of inherent genetic differences, as well as the result of variations in climatic and the edaphic conditions under which the seeds matured. Similar interpretations were made in jack pine[107].

Formation and growth of seed involves a variety of physiological developments. Several metabolic activities are involved during maturation of seeds. With anatomical development of the embryo, numerous food storage activities also take place. Water play a dynamic role in development; transpiration stresses affect seed enlargement, as well as causing expansion and the shrinkage associated with daily hydration and dehydration[197]. Development of seed normally depends on and is regulated by the growth substances produced by the developing ovules. The fluctuations in the levels of growth hormones may reflect in the development behaviour of the seed[282].

Differences in moisture contents of A.pendula seed samples might be due to variation in the level of maturity. It is an assertion that developing seeds undergo a gradual increase in moisture content shortly after pollination till they attain their full dimensions, and as the embryo approaches maturity a very rapid loss in

moisture occurs. At the time of natural seed dispersal the moisture content is essentially reduced to its minimum which might be specific of a species. Thus, comparatively higher moisture content in 'Kardhai' seeds could be attributed to relatively lower level of the seed maturity and vice-versa. The moisture content of a sample, in esse, is one of the most important factors influencing the retention of viability and the general appearance of seeds[168, 182].

A seed must absorb water before it is able to resume growth for the initiation of its germination. Water holding capacity depends upon certain physical characteristics of the seed against osmotic gradient. Table 4.5 is self explanatory. The higher the saturation deficit, the larger will be the osmotic gradient, therefore maximum water will be absorbed by the seeds. Thus saturation deficit relies proportionately on the level of seed maturity and inversely on the seed moisture contents. Hence, more matured and viable seeds with low moisture contents will absorb comparatively large amount of water that is what recorded with the seeds of A.pendula. Since, seeds belonging to Chandpura contained comparatively minimum moisture contents and since they had relatively larger saturation deficit, they might be able to develope maximum osmotic gradient and consequently they absorbed adherently a handsome amount of water. Reverse was the case with the seeds linked with Simravari block, where as , seeds

of other localities ranked in between the two.

Rapid estimation of viability suggest that living seeds varied in composition with regard to sites. Table 4.6 also guides to know that the percentage of non-viable seeds were too much in A.pendula. It might be due to lesser number of fertile seeds in the lot. These results serve to reveal the facts that production of huge amount of unfertile seeds should be held solitarily responsible for the poor germination in 'Kardhai'

It seems that climatic conditions might have played an important role in influencing the developmental processes of A.pendula seeds. A correlative comparison in between the reproductive phase of A.pendula[447] and the prevailing climatic condition becomes all the more significant in order to understand the effect. More or less continuous precipitation during the period of flowering and the time of pollen dispersal, in the months of August and September, has a direct effect in preventing pollination and causing seed abortion. Likewise, experiences of long dry spells with occassional showers at the time of fruit formation might have resulted in the excessive 'Kardhai' seed abortions. These facts were already established in a study regarding reduced production of some gymnosperm's cone[306].

Fruit formation in A.pendula generally initiates at the start of October and fruit-fall lasts upto the end of

February[447]. In other words seeds of A.pendula undergoes maturation in between the months of October and February. Continuous low and occassional freezing temperatures in December and January may reduce the number of sound seeds that survive. This may be either due to killing of the ovules or due to increased sterility of the pollens which disturbed the overall process of fertilization and consequently caused abortion at a later stages of development. A similar relation was found during cone and seed studies in Picea abies[20].

The collective destruction of the seed crop by adverse physiological and the weather conditions and by the biological agents is severe, even though flowers, fruits and seeds of A.pendula are produced in great abundance. The timing and severity of frosts, long dry spells, irregular precipitation etc., all directly affect production of live-seeds in A.pendula. many insects, birds and most of the mammals are dependent at one or the other time on seeds as their prime source of nutrition. Some times insects destroy the seed indirectly. They lay eggs near the developing seeds causing galls to form. Gall formation adjacent to seeds may prevent normal development of the seed.

Bird-damage to flowers and seeds is usually not serious. Squirrels and some species of wild rats represent the most serious threat to the seed development. In addition, they cut and feed on branches, thus destroying both buds and

formation of seeds besides decreasing seed purity in the seed lots.

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C H A P T E R - V

S E E D G E R M I N A T I O N

C H A P T E R - V

S E E D G E R M I N A T I O N

5.1 P R E M I S E

GERMINATION of seed is an important phase in the ecological life history of any species in that it determines the potential of that species to spread, given favourable conditions for establishment.

Germination is the outcome of the interaction of various environmental factors with the intrinsic capabilities of the seeds. The initial step in germination is the reactivation of systems conserved during the seed maturation period. Arousing a dry seed to start growth into a new plant involves four groups of processes, ut infra :

(1). The imbibition of water,

(2). The formation of enzyme systems,

(3). The commencement of growth and radicle emergence, and finally

(4). The growth of the seedling with the characteristic features associated with the subterranean plant upto the time of emergence from the soil[209].

The environment has a profound effect on the germination behaviour, which is brought about in two ways. The environment prevailing during seed formation and the

environment existing during seed germination[192, 232]. Thus germination process is controlled by a system of interacting reactions of the environmental factors. However, in no case the information is available about the exact mechanism by which the germination behaviour is determined by the environment. The major conditions of life or growth necessary for germination are viz., access to water, a suitable range of temperature, oxygen pressure, different concentrations of inorganic salts, inhibitors and for some seeds the exposure to light. It is suggested that the environmental factors control germination by acting on specific sites of metabolic sequences[232].

The germination of seed is variously defined. Some of them are as follows :

* "Seed germination is the resumption of physiological activity by dormant embryo inside the seed."
  - ANONYMOUS.

* "That group of processes which causes the sudden transformation of dry seed into the young seedlings."
  - A.M.MAYER AND A.POLJAKOFF - MAYBER[231].

* "Germination is reactivation of growth, triggered by environmental stimuli as simple as availability of water and oxygen, or as

complex as temperature - light - endogenous inhibitor and promotor interaction."
- W.T.McDONOUGH[234].

5.2 REVIEW OF LITERATURE

SEED germination is a well programmed process controlled by both the internal and the external factors. Seeds do not resume physiological activity until they imbibe a certain amount of water[91, 217]. Water uptake by seed is pre-requisite of germination. It is assumed that the failure of living seeds to germinate, or the delay in the germination is due to insufficient or delayed hydration of the seed[150]. Different duration of imbibition affect the germinative capacity of forest tree seeds[497]. A continuous water stress inhibited seed germination, almost completely at 5 bar water potential in winged beans[190]. In five cultivars of Carthamus tinctorius, the germination percentage declined as the water stress become higher[286].

Magnum opus has been done as regards the study of germination in different seeds[35,36,41,140,220]. Seed-coats have long been considered to be a kind of barrier to water absorption. Such type of impermeability of the seed-coats to water can be over come by increasing the absorbtive power of the inner tissues, which is generally brought about by pre-chilling or by scarification[156]. Recently, effect of different methods of scarification on seed germination has

been studied in various plants[29, 30, 31, 37, 39, 133, 326, 467, 469].

Mechanical scarification and pre-treatment of with conc. H_2SO_4 and HNO_3 stimulated germination in Acacia farnesiana[133]. Sulphuric acid treatment has positive effect on germination of Trema politoria seeds[467]. In Ficus benghalensis, F.glomerata, F.mysorensis and F.religiosa soaking of seeds for 10 minutes in hot water at 60°C gave the highest germination percentage[326]. Conc. sulphuric acid, hot water treatment and the mechanical scarification were found to be beneficial in breaking the seed-coat dormancy and enhancing the germination percentage of the seeds of Prosopis juliflora[39]. For best germination in teak, soaking of the seeds for 48 hours in water and then followed by an alternate drying and soaking (12 hours each) for 21 days is recommended[280]. Hot water treatment was found to give a very good germination and also the higher values of germination velocity index in Leucaena leucocephala seeds[29]. Seeds of Acacia catechu treated with conc. sulphuric acid for 10 and 15 minutes gave better results[30]. Mechanical scarification (filling) and treatment of the seeds with conc. sulphuric acid produced a handsome number of vigorous seedlings in Cassia fistula[31].

Extensive research on seed size effects on various aspects of plant growth pertaining to field crops has been carried out with positive correlation between seed size and

the vigour of the plants. This information is in an infant stage on many of the forest tree species[86, 131, 145, 152, 174, 275, 391, 439]. Differences in seed size within a seed sample are reflected in seedling size in wide range of plants. Size of seeds in many conifers have been found to have a controlling effect on their germination and or on the initial growth of the resulting seedlings[40]. Generally large seeds were found to germinate fast and more completely [99, 303, 349, 494].

The initial field emergence and growth rate for the seedlings of Leucaena leucocephala was found higher in the larger seeds[149]. Large sized and light weighted seeds of Lagerstroemia parviflora are superior as far as their germinability is concerned[391]. Medium sized seeds gave significantly higher mean total germination percent and plant percent as compared to the large or small sized seeds of Pinus spp[131]. A strong relationship of seed weight with several growth factors has been suggested in the early development of Pinus oocarpa seedlings[174]. However, an unusual behaviour has been reported, whereby the smaller seeds of Albizia lebbek gave faster moisture uptake and emergence but low percentage of germination as compared to the large and medium sized seeds[304].

Seed germination may be inhibited by the presence of specific substances in the soil derived from plants of

the same or of different species[222, 234, 299, 453, 489]. Presence of germination inhibitors in the seeds of higher plants is a wide spread phenomenon in nature[114, 116, 343, 344]. Molisch,[254] - the originator of the term 'ALLELOPATHY', was very much aware of the reciprocal biochemical interaction between all types of plants in a ecosystem. Such interactions are known as 'ALLELOCHEMICS' and chemicals involved in such interaction are termed as 'ALLELOPATHINS'[327]. Recently, the use of positive (+) or negative (-) symbolic notations before the term allelopathy has been proposed to denote the beneficial or the harmful effects of it respectively[346].

The author, however, could not resist himself in reproducing the two mirabile dictu definitions of 'ALLELOPATHY' ut infra :

* "A chemical technique of harming population of other species."
  - M.S.ANBAKHT[18].

* "Chemical devices through which some plants can translate environmental cues into internal regulatory controls over growth and development processes."
  - A.C.LEOPOLD AND P.E.KRIEDEMANN[209].

Presence of allelopathins has been demonstrated in one or the other parts of the plants[191, 317, 376, 385, 388, 460]. Spray and soil application of leaf leachated of Clerodendrum viscosum caused reduction in the weight of mustard plants besides chlorosis and leaf fall[74]. The aqueous extract of Cyperus sanguinolenta showed a gradual reduction not only in the percentage germination of the two varieties of paddy but in the shoot-root length and the dry weight as well[125]. The presence of polyphenols in the seed-coat of Acacia nilotica is held responsible for causing problems in obtaining uniform germination of its seeds and also in establishing a homogenous stand of its seedlings[134]. Leaf leachates of both the Mangifera indica and the Shorea robusta are conducive in increasing the percentage and the speed of germination in the seeds of Costus speciosus, whereas, the leaf leachates of both the Tectona grandis and the Eucalyptus sps. showed the inhibitory affect[194]. Seeds of Tridax procumbens when treated with aqueous extracts of Parthenium hysterophorus roots, not only exhibited poor chlorophyll content but also reduced the length of the shoot and the root as well besides causing decrease in dry matter production of the seedlings[317]. Eucalyptus globulus effects adversely, whereas, Aesculus indica had a favourable influence on both the growth of Vigna radiata[361], and the germination of Glaucium flavum[405]. Leaf leachates of the four trees viz.,

Acacia nilotica, Albergia sissoo, Eucalyptus hybrid and Morus alba responded differently with the four selected crops viz., Brassica juncea, Lens esculenta, Pisum sativum and Triticum aestivum. Maximum reduction in the germination percentage and in the germination relative index (GRI) was observed in the seeds of B.juncea when treated with any of the four leachates. The mulberry leachates exhibited maximum toxic effect on each of the four crops[385]. Allelopathins present in Argemone mexicana had shown little effect on the seedling emergence of Brassica, Pennisetum, Raphanus and Triticum spp. However, the later growth of each of the four species was badly affected[388].

The beneficial effect of soaking the seeds with growth regulators (phyto-hormones) and other chemicals has been reported by a great number of workers[59, 81, 103, 129, 144, 354, 441]. Seeds of several species, when soaked in Indole-acetic-acid (IAA) has shown enhancement in their germination behaviour[45, 90, 117, 123, 256, 384], though, the inhibitory effects of IAA has also been reported[264, 384, 418]. Gibberellic acid (GA) treatments can overcome the dormancy of lettuce seeds[172]. It has been found that the emergence from dormancy correlates with an increase in natural GA levels[422]. In rare instances GA applications can actually induce dormancy[263]. It has been established that GA originating from the embryo is responsible for the

hydrolysis of starch reserves in the endosperm during germination of grains[294]. The enhancement in seed germination through GA treatment has been reported in several instances[1, 17, 78, 113, 117, 131, 198, 203, 206, 379, 380, 412]. In Atylosia scarabaeoides the pre-soaking treatment of seeds with GA has shown neither stimulating nor inhibitory effect on the germination behaviour[276]. Similarly, kinetin (KN) did not show much influence on seed germination. It is basically a cell division factor and its role in germination is not yet clear, though, the stimulating effect of KN is reported[259, 263]. Maleic hydrazide (MH) strongly inhibited germination in Leucaena sinoerunia and in Momordica charantia at its high concentrations, however, it did not had any effect on Cucumis sativus and on Citrullus lanatus var. fistulosus[384]. Coumarin caused maximum inhibition in germination in all the species tested and germination decreased with increasing concentration[231, 248].

5.3 M A T E R I A L A N D M E T H O D

FOR germination studies, composit sample of the seeds of Anogeissus pendula, belonging to all the six forest blocks were used. Five replicates of 100 seeds each were taken during all the studies for various treatments on its germination. Mature seeds were selected by floatation test

as recommended[456], and were surface sterilised with 0.1 % mercuric chloride for 2 minutes before placing them to germinate. Emergence of radicle was taken as the main criterion for germination. Observations were recorded *per diem* upto 30 days. The germinated seeds were removed after their count, in order to minimise the difficulties in counting of the freshly germinated seeds. The experiments on the germination studies were carried out in the Ecology Lab., of Bipin Bihari Mahavidyalaya, Jhansi during the months of May and June, 1986.

5.3(a) G E R M I N A T I O N V A L U E

Germination value of seeds was calculated as per the method prescribed by Czabator[99]. Germination value is the product of peak value (PV) of germination and mean daily germination (MDG) *i.e.*,

GV = PV x MDG

Mean daily germination was calculated by dividing the total germination percentage at the end of the test by the number of days since the test began. For calculating peak value, the cumulative germination percentage for each successive day was tabulated. Then working back from the end of the test period, successively earlier cumulative germination percentage were divided by the corresponding number of days. The successive quotient so obtained continued

to increase until the peak value is reached, which was noted. Germination value (GV) was then calculated by multiplying the peak value with the mean daily germination.

5.3(b) E X P E R I M E N T A L D E S I G N

The following experiments were designed in order to study the effects of various treatments on the percentage germination of A.pendula seeds :.

(i). Effect of petri-dish & nursery bed,
(ii). Imbibition,
(iii). Dry and wet heat pretreatment,
(iv). Hot water treatment,
(v). Light conditions,
(vi). Sulphuric acid pretreatment,
(vii). Growth hormones,
(viii). Allelopathy,
(ix). Seed-weight and seed-size, and
(x). Potting media.

5.3(b)-i P E T R I - D I S H & N U R S E R Y B E D

Sterilised seeds of A.pendula were germinated directly, after washing them a fond in running water, on top of both, the double blotters in petri-dishes and the soil in nursery bed separately. Blotters in petri-dishes were kept regularly moist by inspecting them at frequent intervals, whereas, the nursery beds were irrigated bis in die.

5.3(b)-ii I M B I B I T I O N P E R I O D

Sterilized and thoroughly washed seeds were imbibed in glass beakers containing distilled water (250 ml per 100 seeds)[22], for 6, 12, 24, 36, 48 and 60 hours each at three temperature regimes viz., 5°C, 20°C and 35°C. The imbibed seeds were washed a fond in running water and their surface were blotted dry. They were then germinated on top of the two layers of blotters in petri-dishes with semi-closed covers at room temperature 20.3°C (± 2.04). The substratums were kept moist enough so that they may supply the needed moisture to the seeds at all the times. For control unimbibed and rinsed seeds were used.

5.3(b)-iii D R Y & W E T H E A T T R E A T M E N T

Pre-heat treatments were done on dry (unsoaked) and wet (fully turgid) seeds of A.pendula. Both, the soaked and the unsoaked seeds were incubated at a constant temperature of 40°C for 1, 2, 3, 5 and 7 days separately. These seeds were subsequently germinated on top of the double-blotters in petri-dishes at room-temperature (22.4°C ± 1.86). The control consisted of the untreated dry seeds.

5.3(b)-iv H O T W A T E R

Thoroughly washed sterilized seeds were soaked in water for 30 and 60 minutes duration at a constant

temperature of 30° , 50° and 70°C each and also for 1 and 5 minutes duration in aqua bulliens. The treated and the untreated (control) seeds were washed a fond before subjecting them to germination trial in petri-dishes at room-temperature (21.8°C ± 2.12).

5.3(b)-v L I G H T C O N D I T I O N S

Effect of the light and the darkness was investigated by wrapping the dishes for the dark experiment in black polythene sheets and placing them far away from the direct source of light. Only green light was used, whenever germination counts were made and or the distilled water was added. Dishes for the light treatment were continuously exposed to light, supplied by an incandescent (100 watts) bulb kept 50 cm apart from the germinating seeds. For diffuse-light, dishes were placed in shaded positions. The experiment was conducted at room-temperature (21.2°C ± 1.76).

5.3(b)-vi S U L P H U R I C A C I D

Sterilized and thoroughly washed seeds were soaked in concentrated sulphuric acid for different durations viz., 30 sec., 1, 2, 5 and 10 minutes and them were rinsed a fond with all care. Their surface were blotted dry. Unsoaked and rinsed seeds were used as control. The experiment was conducted at room-temperature (21.8°C ± 1.98).

5.3(b)-vii G R O W T H H O R M O N E S

Seeds were soaked for 48 hours continuously in

the aqueous solutions of Indole acetic acid (IAA), Indole butyric acid (IBA), Indole propionic acid (IPA), Napthalene acetic acid (NAA), Gibberellic acid (GA), Kinetin (KN), Maleic Hydrazide (MH) and coumarin (COU) each at four different concentrations viz., 50, 100, 500 and 1000 ppm. Fresh aqueous solutions of each were prepared after a lapse of 24 hrs time and the seeds were subsequently transferred in their respective concentrations for another 24 hrs of soaking. Seeds soaked in distilled water for the same period (Changed after 24 hrs) were considered as control. Treated seeds were washed a fond to remove all the traces of chemicals and then were allowed to germinate in alter idem manner at room temperature (21.6°C ± 2.12).

5.3(b)-viii A L L E L O P A T H Y

Composit

Pure, semi-decomposed and air dried litter of some commonly associated trees viz., Acacia catechu, Acacia nilotica, Bauhinia racemosa, Butea monosperma, Holoptelea integrifolia and also of the Anogeissus pendula were soaked separately in distilled water in 1 : 10 w/v ratio for 24 hours. Similarly, some associated herbs viz., Cassia pumila, Corchorus aestuans, Elytraria acaulis, Eragrostis ciliaris and Rungia repens were freshly collected with their vegetative parts intact and were oven-dried at 70°C for 72 hours. These dried herbs and grass were crushed

into powder each of them separately. The dried and sieved powder of each of the species was soaked in distilled water for 24 hours in 1: 10 w/v *pro rata*. Filtered test solutions of the each type, hereafter known as leachates, were stored in coloured glass bottles. Leachates were further diluted in 1 : 100 w/v ratio by adding appropriate amount of distilled water. Thus two dilutions *viz.*, 1% and 10% of all the leachates were used for treating the seeds of 'Kardhai'.

Sound seeds of *A.pendula* were soaked for 24 hours in each of the mentioned test solutions. For control, seeds were soaked for the same period only in distilled water. Soaked seeds were washed *q'fond* and their surface blotted dry. These were then germinated in petri-dishes *alter idem* at room temperature (20.6°C ± 1.44). The substratums were regularly kept moist with the concerning test solutions (leachates) of the desired dilutions. However, the control was moistened with distilled water only. Seeds under germination trial were washed *per diem* in distilled water before adding the concerned test solutions.

5.3(b)-ix S E E D - W E I G H T & S E E D - S I Z E

The range in the seed-weight (0.0010g - 0.0172 g) and the seed-size (7.00 mm^2 - 61.06 mm^2) as per tables -4.2 and 4.3 respectively, was divided into the following nine weight and size classes :

(1). Heavy (> 0.012 g) - Large (> 43 mm^2),

(2). Heavy - Medium (25 mm^2 - 43 mm^2),

(3). Heavy - Small (< 25 mm^2),

(4). Medium (0.006 g - 0.012 g) - Large,

(5). Medium - Medium,

(6). Medium - Small,

(7). Light (< 0.006 g) - Large,

(8). Light - Medium, and

(9). Light - Small.

Seeds under each of these nine weight-size classes were germinated separately in petri-dishes lined with two layers of blotters and were regularly kept moist by supplying sufficient amount of distilled water at frequent intervals. The experiment was performed at room-temperature (21.4°C ± 2.12).

5.3(b)-x P O T T I N G M E D I A

Sound seeds were germinated at room-temperature (22.2°C ± 2.44) in germination trays (enamelled) of 30 cm X 25 cm X 5 cm size. Each of the tray was filled with one of the following four potting media :

(A) - Sand : Collected from nearby stream,

(B) - Red soil : Collected from uncultivated lands,

(C) - Black soil : Collected from agricultural fields, and

(D) - Peat : Collected from swampy areas along river banks flanked with forest trees.

Each of these soil-types were air dried and were broken up into small particles and then sieved through ISS mesh no. 200 before filling them in the trays. Seed were sown semi-exposed on top of the soil. Trays were irrigated at frequent intervals by light showers using tap water.

5.4 O B S E R V A T I O N S

Cela Va Sans dis that the germination is effected by the internal conditions of the seed and various external factors. To discuss the performance and to reasonably estimate the germination percentage under a given set of condition, it is necessary to know the multidimensional germination behaviour of the seeds. A great number of studies with forest tree seeds had been carried out from this point of view. On the basis of this idea several experiments were conducted with A.pendula seeds in order to understand the effects of various treatments on the percentage of germination. Most of them, however, were conducted under very limited facilities. Any way, the results thus obtained are provided in Tables. Germination style of A.pendula seed is depicted in Fig.- 5.1

A perusal of the data, presented in Table - 5.1, displays that the germination of A.pendula seeds varied an rapport their sites of collection. The values ranged from 1.0 to 11.0 percent. Highest value of average percentage of germination was recorded in the sample of seeds collected from Chandpura forest, whereas, the lowest was recorded in the

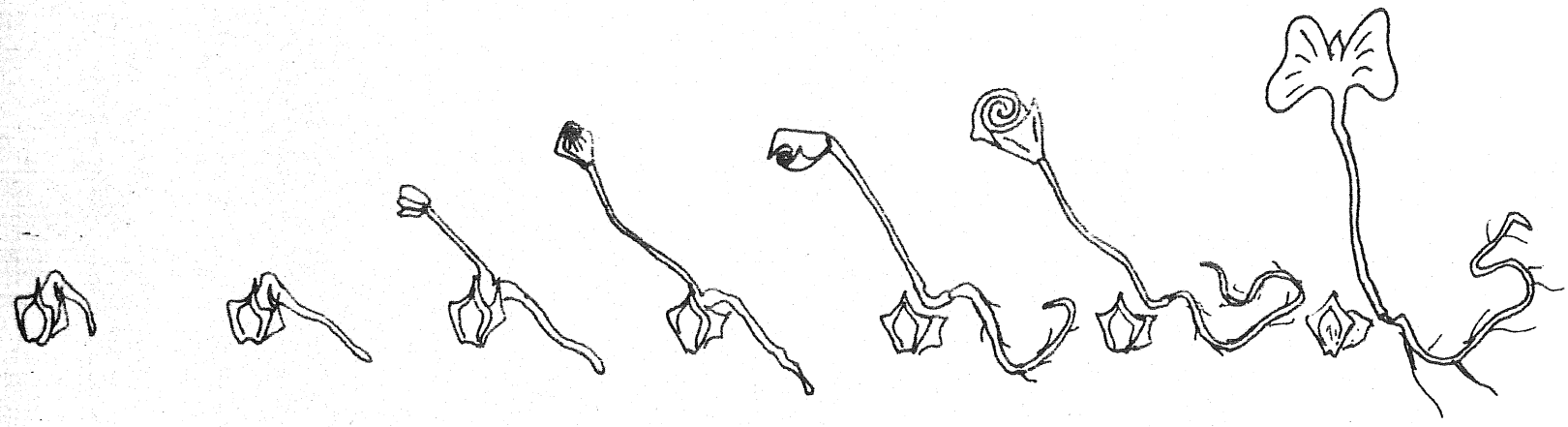


FIG. 5·1 GERMINATION STYLE OF ANOGEISSUS PENDULA SEED·

TABLE - 5.1 NUMBER OF DAYS REQUIRED FOR THE INITIATION OF GERMINATION AND THE GERMINATION PERCENTAGE OF ANOGEISSUS PENDULA SEEDS* AS INFLUENCED BY GERMINATING THEM IN PETRIDISHES AND THE NURSERY BEDS IN RELATION TO SITES.

SUBSTRATUM			SITES OF SEED SOURCES					
			BANGAWA	CHANDJURA	LAXMANPURA	SIMRAVARI	NAYAKHERA	JHARAR
PETRIDISH :								
	I	Av.	5.6	8.8	6.2	4.0	7.6	7.2
		S.E.	± 0.64	± 1.02	± 0.84	± 0.82	± 9.00	± 9.00
		Max.	7.00	11.00	8.00	6.00	9.00	9.00
		Min.	4.00	7.00	5.00	2.00	6.00	6.00
	II	Av.	5.0	4.0	4.6	5.2	4.4	4.4
		S.E.	± 1.12	± 0.54	± 0.98	± 0.80	± 0.76	± 0.92
		Max.	8.00	5.00	6.00	7.00	7.00	6.00
		Min.	4.00	2.00	3.00	4.00	2.00	2.00
NURSERY BED :								
	I	Av.	4.4	7.2	5.4	3.2	6.2	6.0
		S.E.	± 0.56	± 0.84	± 0.62	± 0.44	± 0.78	± 0.58
		Max.	6.00	9.00	8.00	5.000	8.00	8.00
		Min.	3.00	4.00	3.00	1.00	3.00	4.00
	II	Av.	5.8	5.2	5.8	5.4	5.6	5.4
		S.E.	± 0.92	± 0.72	± 0.76	± 0.80	± 0.72	± 0.64
		Max.	8.00	6.00	7.00	7.00	7.00	7.00
		Min.	4.00	4.00	4.00	4.00	5.00	5.00

* 5 Replicates of 100 seeds each

LEGENDS : I = Percentage of Germination, II = Emergence time (days), Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

seeds gathered from Simravari forest with 3.3 and 4.0 percent respectively in petri-dishes, and 7.2 and 3.2 percent respectively in nursery beds (Fig.- 5.2).

The emergence time i.e., the number of days after which the germination of seed started was also found to vary with respect to sites. It ranged between 3 to 8 days after the commencement of the experiment. Highest average values of the number of days required for the initiation of germination, as recorded, was 5.2 in the seeds belonging to Simravari forest when germinated on top of the blotters in petri-dishes. On the other hand, the highest average of emergence time required for germination in nursery beds was 5.8 days - recorded in the seed lots of two different sites viz., Bangawa and Laxmanpura. Seeds collected from Chandpura forest recorded lowest average of 4.0 and 5.2 days in petri-dishes and in nursery beds respectively. The quickest initiation of germination in just 2 days was noticed in some of the replicates containing seeds from Chandpura, Maya-khera and Jharar forests. The longest period of time consumed ab ovo for the initiation was 8 days and was observed in two replicates of seeds from Bangawa - one each in both, the petri-dish and the nursery bed.

The data on the behaviour of germination, as affected by temperature and duration of soaking is presented

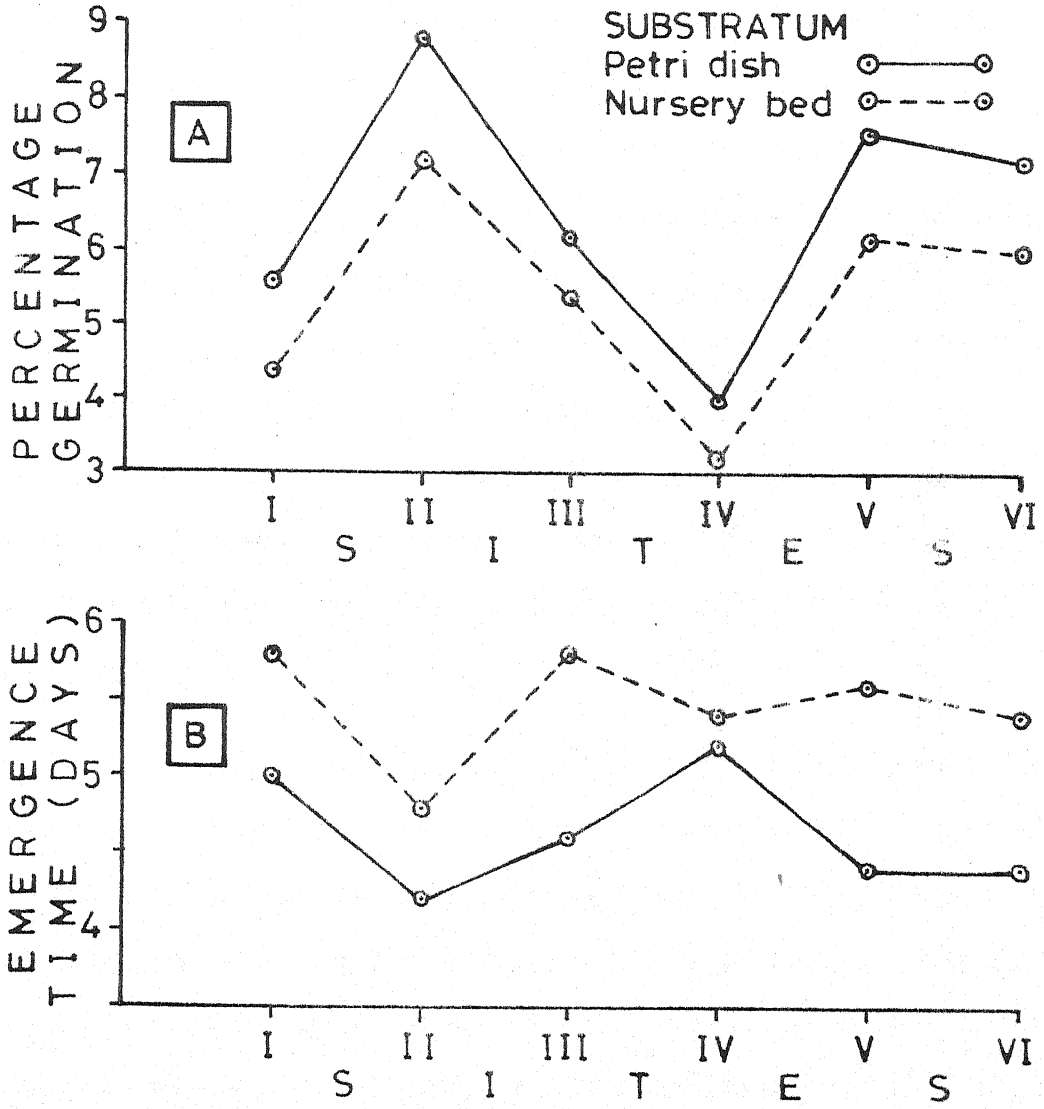


FIG. 5.2 (A) PERCENTAGE GERMINATION AND (B) NUMBER OF DAYS REQUIRED FOR INITIATION BY A. PENDULA SEEDS IN RELATION TO SITES AND THE SUBSTRATUM.

in Table 5.2 which suggest that the soaking of seeds gradually increases the germination percentage with the increase in both, the temperature and the duration of soaking. Seeds soaked at room temperature (20°C) exhibited an average of 10.4 percent of germination after 48 hours or more of the soaking which was 23.81 percent increase in relation to the germination in control. Seeds soaked at 35°C temperature for a minimum of 24 hours time, showed an average of 10.6 percent germination i.e., 26.18 percent increase over control (Fig.- 5.3a). However, the seeds soaked at low temperature of 5°C depict gradual decrease in germination percentage with progressive increase in the duration of soaking. An average of 4.8 percent germination was recorded in seeds soaked for 60 hours at 5°C temperature.

Table 5.3 specifies the effects of pre-heat treatment (40°C) on the germination behaviour of A.pendula seeds. It informs that an incubation for two days of wet seeds attained an average of 11.6 percent germination which was nearly 41.46 percent gain over the control (Fig.- 5.3b). Thereafter, with the increase in the duration of incubation (heat treatment) of soaked seeds a gradual decline in germination percentage was noticed. In other words, prolonging the duration of heat treatment beyond two days at a constant temperature of 40°C, decreased the germination percentage.

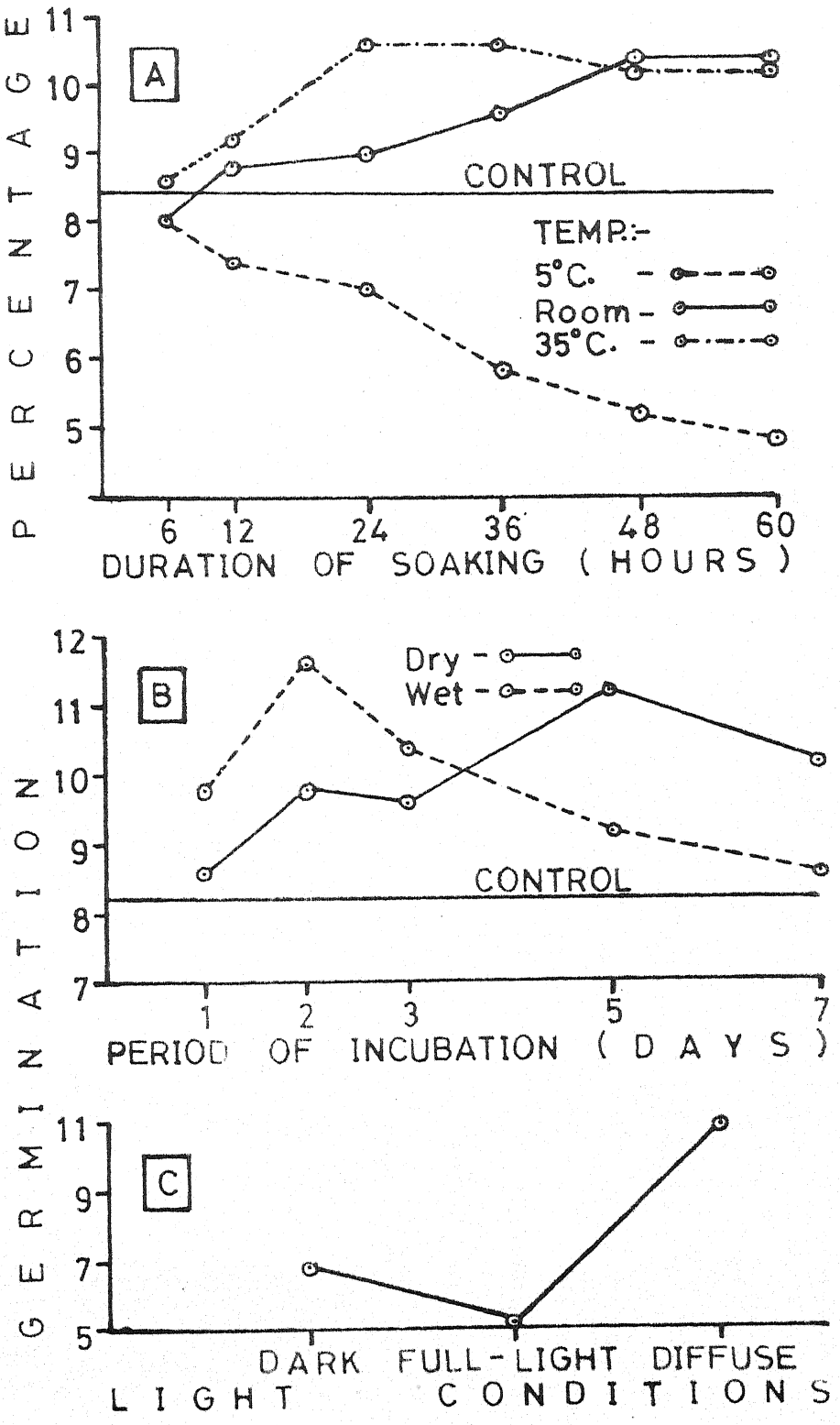


FIG. 5.3- THE GERMINATION PERCENTAGE OF A. PENDULA SEEDS AS AFFECTED BY (A) TEMPRATURE AND THE DURATION OF SOAKING, (B) DRY AND THE WET HEAT PRETREATMENT (40°C.), AND (C) THE LIGHT CONDITIONS.

TABLE - 5.2 GERMINATION PERCENTAGE OF ANOGEISSUS PENDULA SEEDS* AS AFFECTED BY TEMPERATURE AND THE DURATION OF SOAKING IN DISTILLED WATER.

TEMPERATURE		DURATION OF SOAKING						CONTROL
		6 HOURS	12 HOURS	24 HOURS	36 HOURS	48 HOURS	60 HOURS	
5° C	Av.	8.0 ± 0.43	7.4 ± 0.56	7.0 ± 0.32	5.8 ± 0.40	5.2 ± 0.53	4.8 ± 0.56	-
	S.E.							-
	Max.	9.0	9.0	8.0	7.0	7.0	5.0	-
	Min.	7.0	6.0	6.0	5.0	4.0	3.0	-
ROOM TEMP.	Av.	8.0 ± 0.64	5.8 ± 0.72	9.0 ± 0.48	9.6 ± 0.12	10.4 ± 0.30	10.4 ± 0.24	8.4 ± 0.68
	S.E.							
	Max.	9.0	10.0	10.0	10.0	11.0	12.0	9.0
	Min.	6.0	7.0	8.0	9.0	9.0	10.0	6.0
35° C	Av.	8.6 ± 0.92	9.2 ± 0.46	10.6 ± 0.78	10.6 ± 0.84	10.2 ± 0.36	10.2 ± 0.40	-
	S.E.							-
	Max.	10.0	10.0	12.0	12.0	11.0	11.0	-
	Min.	7.0	8.0	9.0	9.0	9.0	9.0	-

* 5 Replicates of 100 seeds each

LEGENDS : Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

TABLE - 5.3 PERCENTAGE OF GERMINATION OF *ANOGEISSUS PENDULA* SEEDS* AS AFFECTED BY DRY AND WET HEAT PRE-TREATMENT (40° C) FOR VARIOUS DURATIONS.

TREATMENT	PERIOD OF INCUBATION (DAYS)					
	1	2	3	5	7	CONTROL
UNSOAKED (DRY)						
Av.	8.6	9.8	9.6	11.2	10.2	8.2
S.E.	± 0.78	± 1.64	± 0.94	± 1.02	± 1.50	± 1.24
Max.	10.0	13.0	11.0	13.0	12.0	10.0
Min.	7.0	7.0	8.0	10.0	7.0	6.0
SOAKED (WET)						
Av.	9.8	11.6	10.4	9.2	8.6	-
S.E.	± 0.82	± 1.44	± 1.06	± 0.94	± 1.28	-
Max.	11.0	14.0	13.0	11.0	11.0	-
Min.	8.0	10.0	9.0	8.0	7.0	-

* 5 Replicates of 100 seeds each

LEGENDS : Av. : Average, S.E. : Standard error, Max. : Maximum, Min. : Minimum

In dry (unscarred) treatment the germination increased upto 5 days of incubation with 36.59 percent increase over control. Incubation of more than 5 days decreased the germination percentage.

Table 5.4 expresses the data regarding influence of temperature and duration of hot water treatments on the germination manners of A.pendula seeds. The table narrates that 60 minutes treatment of the seeds in 50°C hot water gave a maximum average of 10.2 percent germination in comparison to 8.2 percent germination, as recorded, in the control. Treatments below and or beyond 50°C temperature proposed decrease in germination percentage regardless of the duration of the treatment (Fig.- 5.4a). Treatments beyond 70°C temperature was found to be detrimental to seed-germination. The longer the duration of such treatments the more deteriorating impact it had on the total germination percentage. At 100°C temperature, a treatment of 1 minute gave only 1.6 percent of an average germination, whereas, a treatment of 5 minutes at the same temperature gave as low as 0.2 percent of an average germination. Thus, the results hint that in this experiment the method for obtaining maximum germination seems to be a hot water treatment at 50°C temperature for 60 minutes duration.

For making to know the effects of light conditions on the germination behaviour of A.pendula seeds, a look into the Table 5.5 reveals the fact that exposure of seeds to

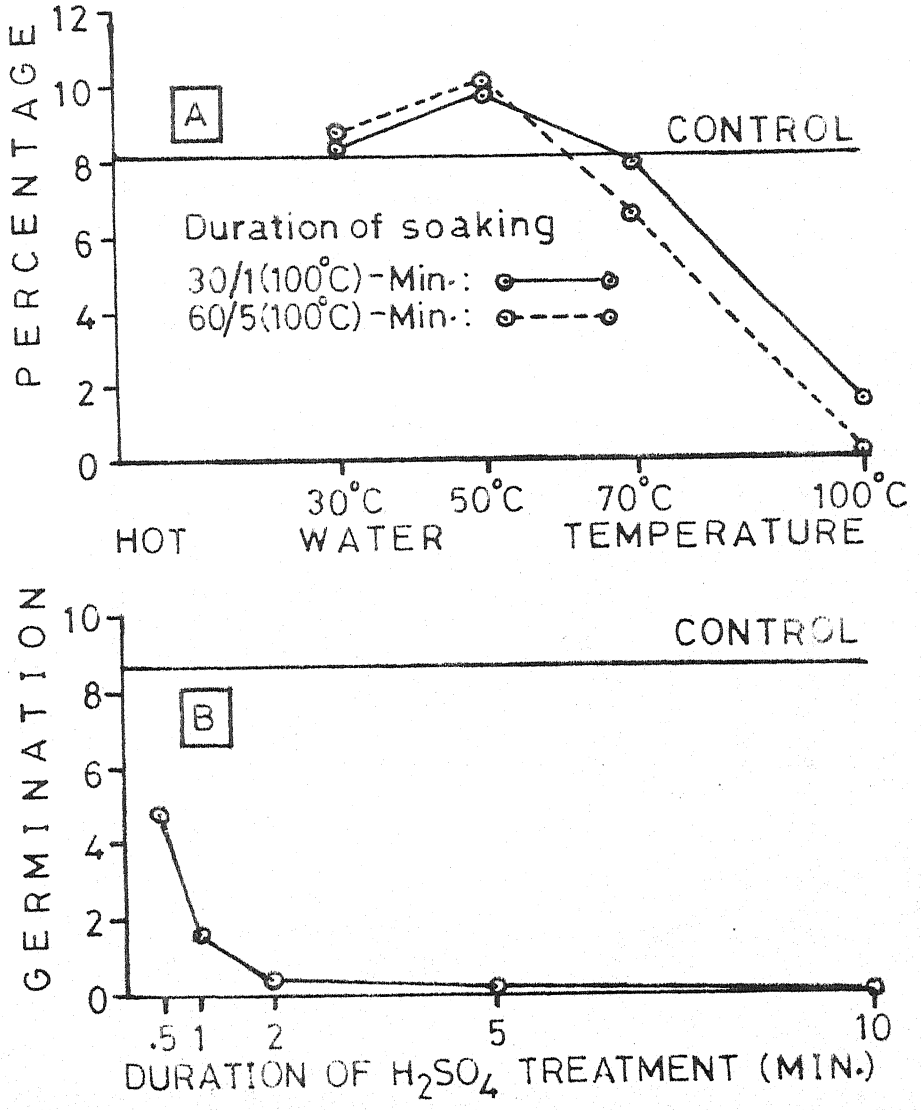


FIG. 5.4 GERMINATION PERCENTAGE OF A. PENDULA SEEDS AS INFLUENCED BY (A) THE TEMPERATURE AND THE DURATION OF HOT WATER TREATMENT & (B) THE SULPHURIC ACID TREATMENTS.

TABLE - 5.4 GERMINATION PERCENTAGE OF ABELMOSCHUS PENDULA SEEDS* AS INFLUENCED BY TEMPERATURE AND THE DURATION OF HOT WATER TREATMENTS.

DURATION OF TREATMENTS	TEMPERATURE OF WATER				
	30° C	50° C	70° C	100° C	CONTROL
I :					
Av.	8.4	9.8	8.0	1.6	8.2
S.E.	± 0.72	± 1.28	± 1.64	± 0.84	± 0.76
Max.	10.0	12.0	11.0	3.0	9.0
Min.	7.0	6.0	5.0	0.0	7.0
II :					
Av.	8.8	10.2	6.6	0.2	-
S.E.	± 0.98	± 0.80	± 1.02	± 0.76	-
Max.	11.0	12.0	7.0	1.0	-
Min.	7.0	7.0	5.0	0.0	-

* 5 Replicates of 100 seeds each

LEGENDS : Treatments : I : 30 minutes, II : 60 minutes
For 100° C it was 1 minute and 5 minutes duration respectively
Av. : Average, S.E. : Standard error, Max. : Maximum, Min. : Minimum

TABLE - 5.5 EFFECT OF LIGHT CONDITIONS ON THE GERMINATION BEHAVIOUR (PERCENTAGE) OF *ARGEMONE PENDULA* SEEDS*.

CALCULATION HEADS	LIGHT CONDITIONS		
	DARKNESS	FULL LIGHT	DIFFUSE LIGHT
Av.	6.8	5.2	10.8
S.E.	± 0.88	± 1.22	± 0.64
Max.	9.0	8.0	12.0
Min.	5.0	2.0	9.0

* 5 Replicates of 100 seeds each

LEGENDS : Av. : Average, S.E. : Standard error,
Max. : Maximum, Min. : Minimum,

continuous light or to complete darkness relatively mitigates germination percentage. On the other hand, an enhancement in germination was recorded in diffused light conditions (Fig.- 5.3c). Average percentage of germination in each of the three light conditions viz., total dark, full light and the diffuse light were 6.8, 5.2 and 10.8 percent respectively.

Table 5.6 discloses the influence of concentrated sulphuric acid on germination behaviour of A.pendula seeds. It is evident from the data that the sulphuric acid treatment has a retarding effect on the germination percentage. A minimum of 30 second of treatment showed 44.19 percent decrease in germination in relation to control i.e., there was 4.8 percent germination as compared to the 8.6 percent in control (Fig.- 5.4b). One minute treatment exhibited an average germination of 1.6 percent which was, in fact a decrease of 81.4 percent in relation to control. Treatments for 2 and for 5 minutes duration illustrates only 0.4 and 0.2 percent of germination respectively. However, no seeds could germinate in 10 minutes duration of sulphuric acid treatment.

The results of the effects of soaking of seeds in different aqueous concentration of auxins are provided in table 5.7(a). The data suggests that treatment of seeds with Indole butyric acid had some noticeable stimulating

TABLE - 5.6 INFLUENCE OF CONCENTRATED SULPHURIC ACID ON THE GERMINATION PERCENTAGE OF *ARGEMONE MEXICANA* SEEDS*.

CALCULATION	SULPHURIC ACID TREATMENT					
	30 Sec.	1 M.	2 M.	5 M.	10 M.	CONTROL
Av.	4.8	1.6	0.4	0.2	0.0	8.6
S.E.	± 0.78	± 0.82	± 0.56	± 0.68	± 0.00	± 0.66
Max.	7.0	3.0	1.0	1.0	0.0	10.0
Min.	3.0	1.0	0.0	0.0	0.0	8.0

* 5 Replicates of 100 seeds each

LEGENDS : Av. : Average, S.E. : Standard, Max. : Maximum, Min. : Minimum, Sec. : Seconds, M. : Minute(s)

TABLE - 5.7.(a) GERMINATION PERCENTAGE OF ANOGEISSUS PENDULA SEEDS* AS AFFECTED BY SOAKING THEM IN DIFFERENT CONCENTRATIONS OF SOME AUXINS.

CONCENTRATIONS		A U X I N S				CONTROL
		INDOLE ACETIC ACID	INDOLE BUTYRIC ACID	INDOLE PROPIONIC ACID	NAPHTHALENE ACETIC ACID	
50 ppm	Av.	8.2	8.4	8.0	8.2	8.0
	S.E.	± 0.92	± 0.64	± 0.72	± 0.58	± 0.44
	Max.	10.0	10.0	10.0	10.0	9.0
	Min.	6.0	7.0	7.0	7.0	7.0
100 ppm	Av.	8.4	8.8	8.2	8.6	-
	S.E.	± 0.36	± 0.42	± 0.64	± 0.28	-
	Max.	10.0	10.0	10.0	10.0	-
	Min.	8.0	8.0	7.0	8.0	-
500 ppm	Av.	8.4	11.2	8.6	9.2	-
	S.E.	± 0.32	± 1.18	± 0.78	± 0.46	-
	Max.	10.0	14.0	10.0	10.0	-
	Min.	8.0	10.0	7.0	8.0	-
1000 ppm	Av.	7.6	15.4	8.4	8.4	-
	S.E.	± 1.08	± 0.96	± 0.54	± 0.62	-
	Max.	9.0	18.0	10.0	10.0	-
	Min.	5.0	14.0	7.0	7.0	-

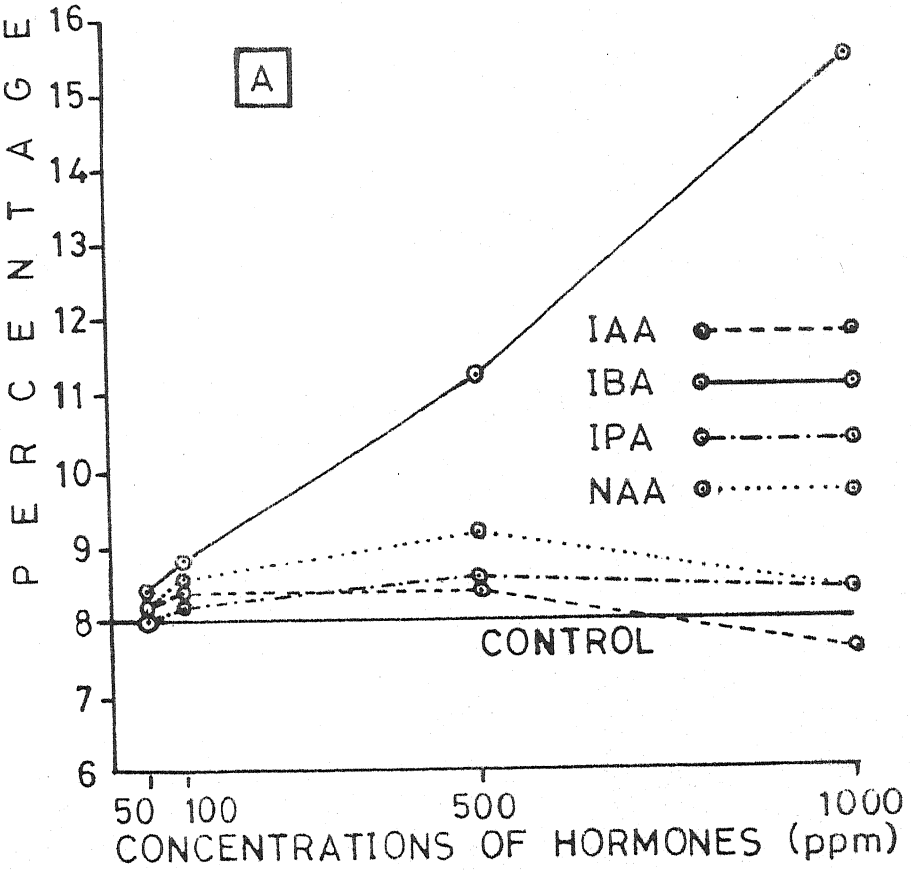
* 5 Replicates of 100 seeds each

LEGENDS : ppm = part per million

Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

effect on germination behaviour. All other auxins used had shown no any significant increase or decrease in the average germination of A.pendula seeds. Out of the four different concentrations used for soaking, the seeds soaked in 1000 ppm/IBA attained a maximum average of 15.4 percent germination as against of 8.0 percent in control i.e., 92.5 percent increase in the germination over the control (Fig.- 5.5a). This was followed by 500 ppm/IBA treatment which exhibited 11.2 percent germination - a 40 percent increase in relation to the control.

During germination studies under auxin treatments, three aberrant seedlings with tricotylous characters were noticed on 20th day of germination (Plate - 27) one each in 1000 ppm/IAA, 50 ppm/ IBA and 1000 ppm/IBA treatments. A comparative account including photosynthetic area, plant length and shoot/root ratio of these aberrant tricotylous and the normal dicotylous (5 replicates each obtained from the respective treatments and from the control as well) seedlings is provided in Table 5.7(b). The total photosynthetic area of each of these tricotylous seedlings were comparatively lesser than that of the normal seedlings under respective auxin treatments as well as of the normal seedlings under control. An average photosynthetic area of the normal seedlings under control was 283 sq mm, whereas, under the respective treatments it was 218 sq mm, 275 sq mm and 350 sq mm in 1000 ppm/IAA, 50ppm/IBA and 1000 ppm/IBA respectively in comparison



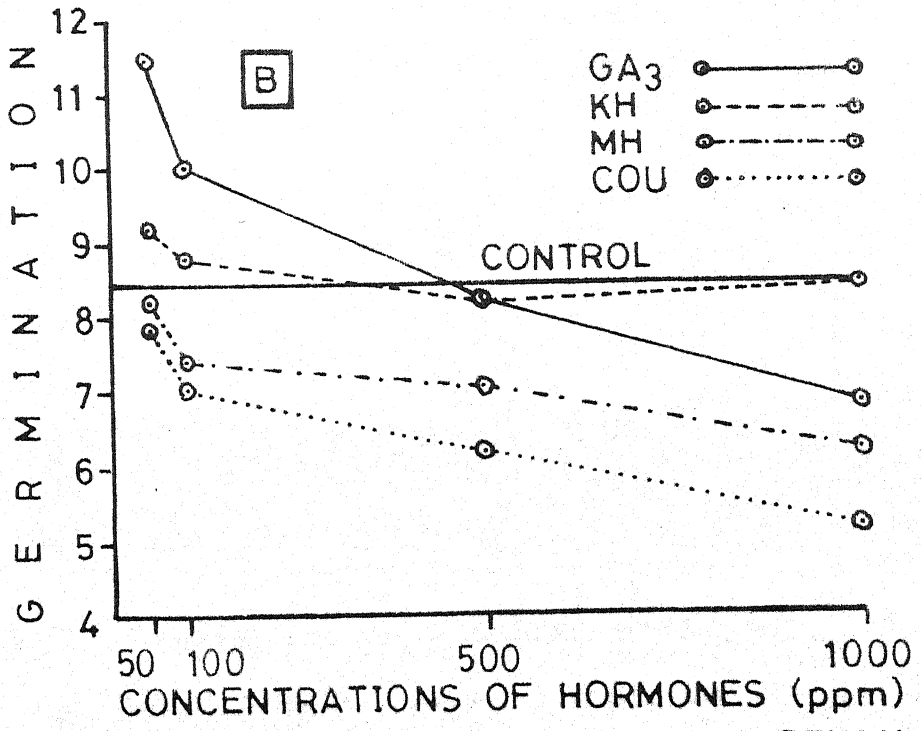


FIG. 5.5 GERMINATION PERCENTAGE OF A. PENDULA SEEDS AS AFFECTED BY SOAKING THEM IN VARIOUS DILUTIONS OF (A) SOME AUXINS AND (B) SOME OTHER GROWTH HORMONES.

TABLE - 5.7.(b) GROWTH AND THE DRY MATTER PRODUCTION AND S/R RATIO IN NORMAL (DICOTYLOUS) AND THE ABERRANT (TRICOTYLOUS) SEEDLINGS OF ARGEMONE MEXICANA.

TREATMENT	LEAF AREA(mm^2)	PLANT LENGTH(mm)	SHOOT / ROOT	
			LENGTH	DRY WEIGHT
1000 ppm/IAA				
N : Av.	218.00	43.00	1.389	1.186
S.E.	± 3.12	± 2.44	± 0.642	± 0.488
A : Av.	180.00	26.00	1.364	1.250
50 ppm/IBA				
N : Av.	275.00	55.00	0.667	0.599
S.E.	± 5.76	± 3.24	± 0.092	± 0.088
A : Av.	243.00	43.00	1.067	1.487
1000 ppm/IBA				
N : Av.	350.00	49.00	1.333	1.214
S.E.	± 5.76	± 4.22	± 0.286	± 0.464
A : Av.	254.00	55.00	1.292	1.183
Control (d.w.)				
N : Av.	283.00	36.00	1.571	1.347
S.E.	± 4.66	± 3.64	± 0.874	± 0.664
A : Av.	Absent	Absent	Absent	Absent

LEGENDS : Treatment : IAA : Indole acetic acid, IBA : Indole butyric acid, (d.w.) : Distilled water, ppm : parts per million, N : Normal (dicotylous), A : Aberrant (Tricotylous), Av. : Average, S.E. : Standard error, mm : Milimeter

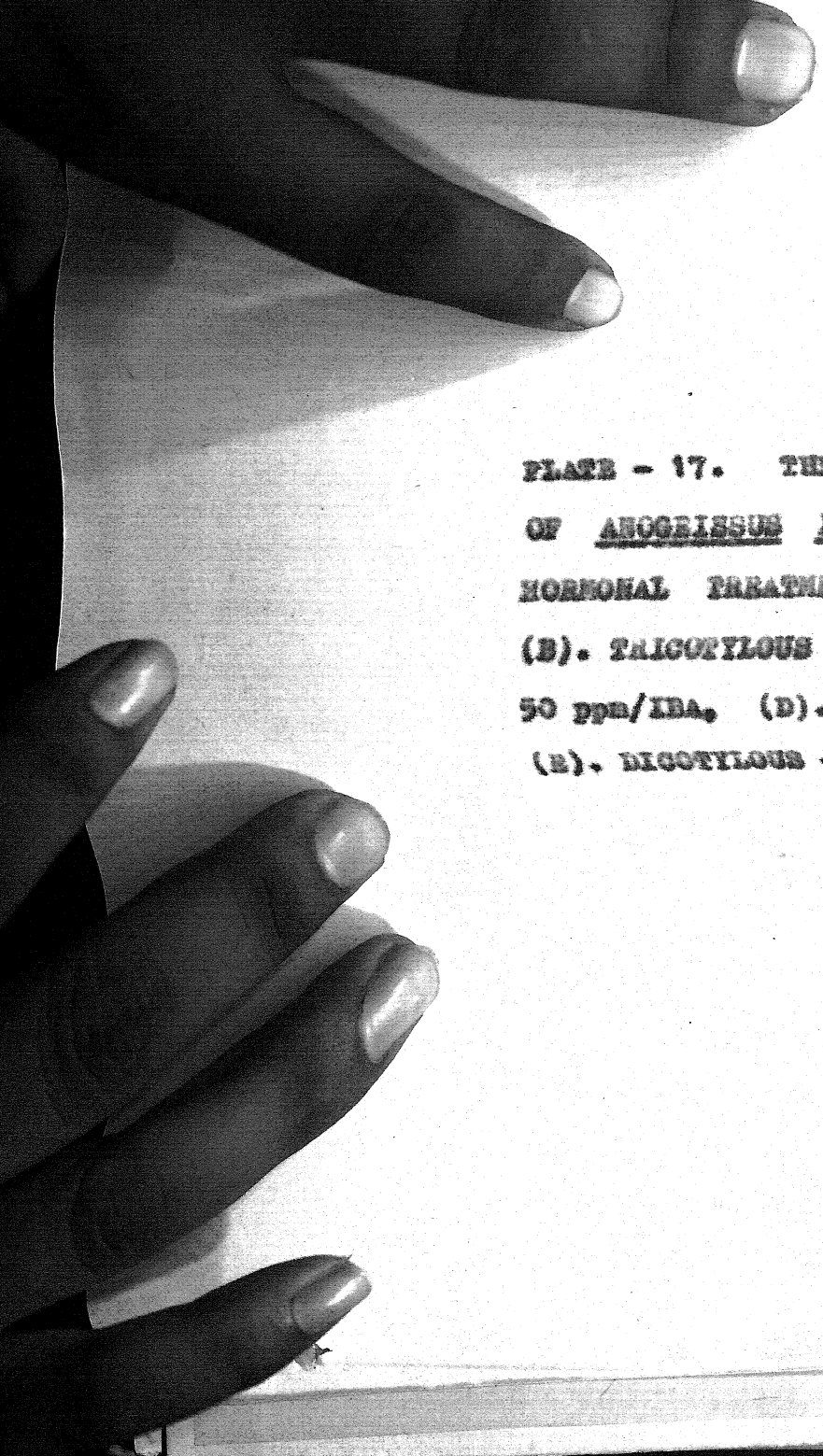


PLATE - 17. THE ABERRANT AND THE NORMAL SEEDLINGS OF ANOGEISSUS PENDULA OBTAINED IN THE FOLLOWING HORMONAL TREATMENTS : (A). TRICOTYLOUS - 1000 ppm/IAA, (B). TRICOTYLOUS - 1000 ppm/IBA, (C). TRICOTYLOUS - 50 ppm/IBA, (D). DICOTYLOUS - 1000 ppm/IBA, AND (E). DICOTYLOUS - CONTROL IN DISTILLED WATER.

with the total photosynthetic area of the aberrant seedlings in order of 180 sq mm/1000 ppm -IAA, 243 sq mm/50 ppm-IBA and 254 sq mm/1000 ppm -IBA. The size of the normal and the aberrant seedlings making their appearance in the respective auxin treatments were comparatively 19.44 to 25 percent more (excluding the data of the length of tricotylous seedling obtained in 1000 ppm/IAA) than the size of the normal seedlings collected from t e seeds germinated in the control. An average length of the normal seedling under control was 36 mm, whereas, under respective auxin treatments it was 43 mm in 1000 ppm/IAA, 55 mm in 50 ppm/IBA and 49 mm in 1000 ppm/IBA as compared with the average length of the aberrant seedlings in order of 26 mm, 43 mm and 55 mm respectively.

Table 5.7(c) presents the average germination percentage of A.pendula seeds as affected by soaking them in different concentrations of some hormones excluding auxins. It was not possible due to limited facilities, to carry out this experiment simultaneously while making a study on the effect of auxins in the laboratory. Hence, this experiment was laid separately. The data manifests that GA animates the germination of A.pendula seeds only when used in low concentrations of 50 ppm and also of 100 ppm (Fig.- 5.5b). An increase of 35.71 percent germination over control was noticed in 50 ppm/GA as against 19.05 percent increase in 100 ppm/GA. A higher conc., of 1000 ppm/GA gradually

TABLE - 5.7.(c) GERMINATION PERCENTAGE OF ANOGEISSUS PENDULA SEEDS* AS AFFECTED BY SOAKING THEM IN DIFFERENT CONCENTRATIONS OF SOME HORMONES (OTHER THAN AUXINS).

HORMONAL CONCENTRATIONS		H O R M O N E S				CONTROL
		GIBBERELLIC ACID	KINETIN	MALEIC HYDRAZIDE	COUMARIN	
50 ppm :	Av.	11.4	9.2	8.2	7.8	8.4
	S.E.	± 1.03	± 0.76	± 0.52	± 0.66	± 0.54
	Max.	14.0	11.0	10.0	9.0	10.0
	Min.	9.0	7.0	7.0	6.0	7.0
100 ppm :	Av.	10.0	8.8	7.4	7.0	-
	S.E.	± 0.58	± 0.42	± 0.89	± 0.58	-
	Max.	12.0	10.0	10.0	9.0	-
	Min.	9.0	7.0	6.0	6.0	-
500 ppm :	Av.	8.2	8.2	7.0	6.2	-
	S.E.	± 0.76	± 0.84	± 1.06	± 0.34	-
	Max.	10.0	10.0	9.0	7.0	-
	Min.	6.0	6.0	4.0	5.0	-
1000 ppm :	Av.	6.8	8.4	6.2	5.2	-
	S.E.	± 0.36	± 0.28	± 0.76	± 1.12	-
	Max.	9.0	9.0	8.0	8.0	-
	Min.	5.0	7.0	4.0	3.0	-

* 5 Replicates of 100 seeds each

LEGENDS : ppm = part per million

Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum.

diminishes germination percentage. Kinetin (KN) was effective neither in increasing nor in decreasing the germination percentage of A.pendula seeds. However, the lower concentration of 50 ppm/KN seems to have a slightly encouraging effect with only 9.52 percent increase in germination in relation to the control. Maleic Hydrazide (MH) and the Coumarin (COU) seems to alleviate the germination percentage with the corresponding increase in their concentrations at all the levels of treatments. Maximum 38.95 percent decrease in relation to control was noticed in 1000 ppm/COU.

Table 5.8(a) serves to make know the allelopathic effects of 'Kardhai' and some other associated trees on the germination fashion of A.pendula seeds, whereas, the Table 5.8(b) displays the allelopathic effects of some associated herbs on the custom of germination in A.pendula seeds. Data documented in Table 5.8(a) narrates that the leachates of both, the Acacia catechu and the Acacia nilotica have inhibitory effects on the germination of 'Kardhai' seeds. At 1 percent concentration of the leachate, both, A.catechu and the A.nilotica checked 28.57 and 23.81 percent germination respectively as compared with that of the control. At 10 percent conc., they inhibited 38.95 and 30.95 percent of germination in relation to the control (Fig.- 5.6a). Thus with respect to A.pendula, both, the A.catechu and the A.nilotica are negatively (-) related allelochemics.

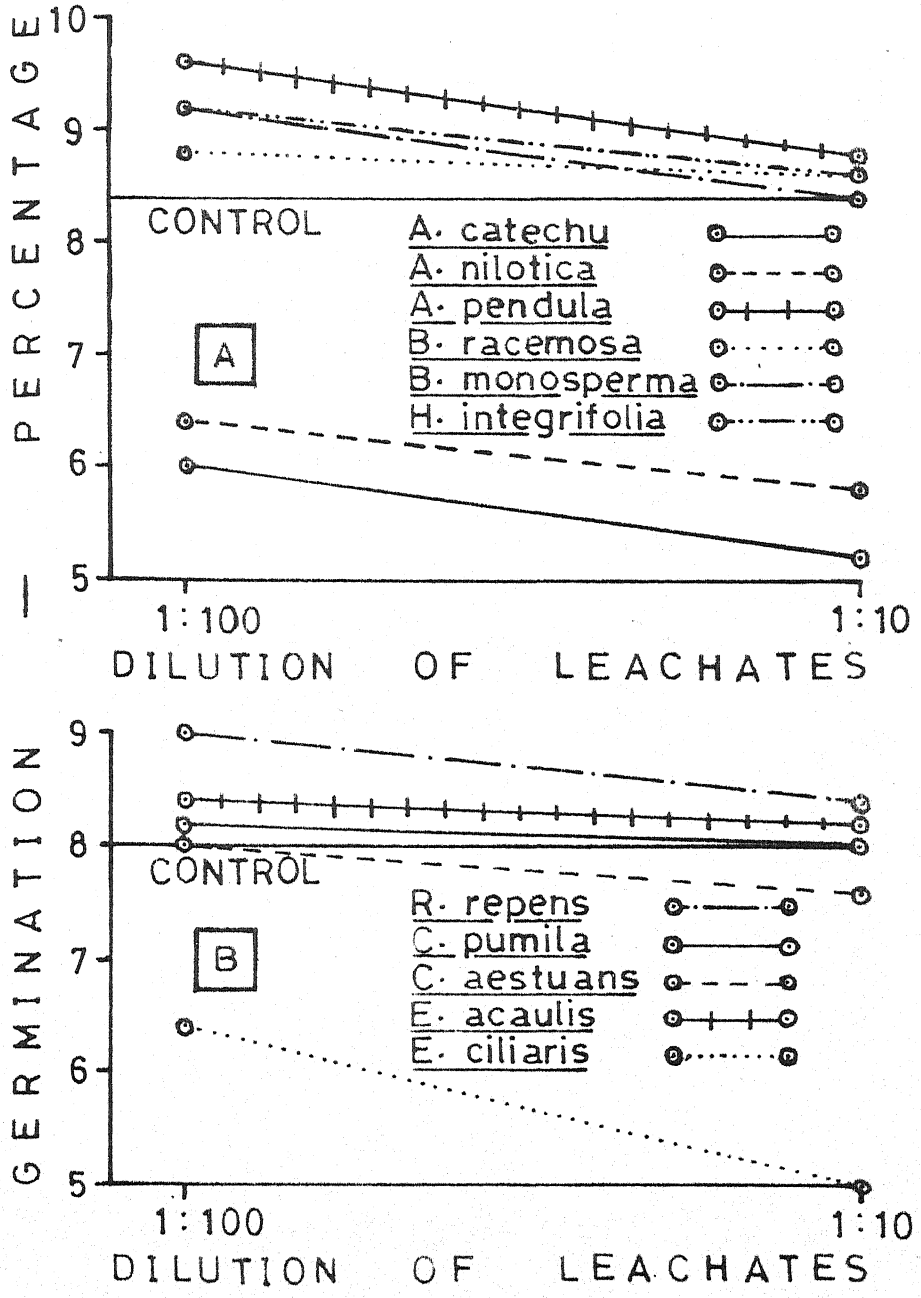


FIG. 5.6 ALLELOPATHIC EFFECTS OF TWO DILUTIONS OF VARIOUS PLANT LEACHATES ON THE GERMINATION PERCENTAGE OF A. PENDULA SEEDS.

TABLE - 5.8.(a) ALLELOPATHIC EFFECT OF 'KANDHAI' AND SOME ASSOCIATED TREE SPECIES ON THE GERMINATION PERCENTAGE OF A. PENDULA SEEDS*.

DILUTION	LEACHATE TYPE						
	A	B	C	D	E	F	CONTROL
I : Av.	6.0	6.44	9.6	8.8	9.2	9.2	8.4
S.E.	± 0.94	± 1.28	± 1.66	± 0.82	± 1.34	± 0.98	± 1.02
Max.	7.0	8.0	12.0	11.0	11.0	11.0	11.0
Min.	4.0	4.0	8.0	8.0	7.0	8.0	7.0
II: Av.	5.2	5.8	8.8	8.6	8.4	8.6	-
S.E.	± 1.16	± 0.98	± 0.44	± 0.80	± 0.64	± 1.24	-
Max.	7.0	7.0	9.0	10.0	10.0	10.0	-
Min.	4.0	5.0	8.0	8.0	8.0	7.0	-

* 5 Replicates of 100 seeds each

LEGENDS : Dilutions : I = 1 : 100, II = 1 : 10,

Leachate type : A = Acacia catechu, B = Acacia nilotica,

C = Anogeissus pendula, D = Bauhinia racemosa, E = Butea monosperma,

F = Holoptelia integrifolia

Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum,

Leachates of Butea monosperma and of Holoptelea integrifolia both have some instigating effects on the germination pattern of A.pendula seeds when used at 1% dilution. 10% conc., of the same leachates appears to have no noticeable effect on the style of the germination. The leachates of the same plant (A.pendula) was more effective than that of the B.monosperma and the H.integrifolia in stimulating the germination at 1% dilution. It offered 14.29 percent profit in germination with respect to the germination in control. Leachates of Bauhinia racemosa doesn't have any allelopathic effect on the mode of germination of 'Kardhai' seeds.

Similarly, the study with the leachates of some herbs discloses the facts that leachates of only Eragrostris ciliaris has a inhibitory effect on A.pendula seeds (Table 5.8b) at both the level of its dilution. The impact of inhibition increased with the increase in the concentration (Fig.- 5.6b). At 1% level of dilution there was 20 percent decrease in the germination of 'Kardhai' seeds, whereas, at 10% level of conc., the decrease in germination was 37.5% in relation to the germination in control. On the other hand, the leachates of Mungia repens also exhibited slightly exciting effect on the germination behaviour of the seeds only at the lower level of its dilution. It increased the germination upto 12.5% at 1 percent level of its dilution in relation to the control. The leachates of Cassia pumila.

TABLE - 5.8.(b) ALLELOPATHIC EFFECT OF SOME HERBS ON THE GERMINATION PERCENTAGE OF *AMORPHOPHUS PENDULA* SEEDS*.

DILUTION	LEACHATE TYPE					
	A	B	C	D	E	CONTROL
I : Av.	8.2	8.0	8.4	6.4	9.0	8.0
S.E.	± 0.94	± 0.88	± 1.12	± 1.00	± 0.94	± 1.08
Max.	9.0	9.0	10.0	8.0	11.0	9.0
Min.	7.0	7.0	7.0	6.0	8.0	6.0
II : Av.	8.0	7.6	8.2	5.0	8.4	-
S.E.	± 0.72	± 0.96	± 1.02	± 0.90	± 0.88	-
Max.	10.0	9.0	9.0	6.0	10.0	-
Min.	7.0	7.0	8.0	4.0	7.0	-

* 5 Replicates of 100 seeds each

LEGENDS : Dilutions : I = 1 : 100, II = 1 : 10.

Leachate type : A = *Cassia pumila*, B = *Corchorus aestuans*, C = *Elytraria acaulis*, D = *Eragrostis ciliaris*, E = *Euphorbia hirta*.

Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

Corchorus aestuans and the Blytraria acaulis seems to have neither stimulatory nor inhibitory effect on the mode of germination of A.pendula seeds.

The data inscribed in the Table 5.9 envisages the effect of weight and the size of A.pendula seeds on germination deportment. The results thus obtained suggest that the medium sized - heavy weighted seeds were having an upper hand in attaining a maximum average of 34.2% germination. Medium sized - medium weighted seeds were proxime accessit in gaining 15.4% germination. The rest of the nine weight and size classes were in the following et.seq., : small sized - heavy weighted > small sized - medium weighted > large sized - medium weighted > large sized - heavy weighted > medium sized-light weighted > large sized - heavy weighted > small sized - light weighted > large sized - light weighted. Sprouting in the large sized seeds was relatively much less with only 2.8, 3.0 and 0.6 percent of germination in heavy, medium and the light weighted seeds respectively. Germination of small sized seeds was also low in comparision with the medium sized seeds. Small sized seeds displayed 5.2, 3.8 and 1.8 percent of germination in heavy, medium and the light weighted seeds respectively. Similarly, only 2.4% germination was recorded in the medium sized - light weighted seeds (Fig.- 5.7a). Collectively, the germination was 2.13, 17.33 and 3.6 percent of the total in large, medium and the small sized seeds

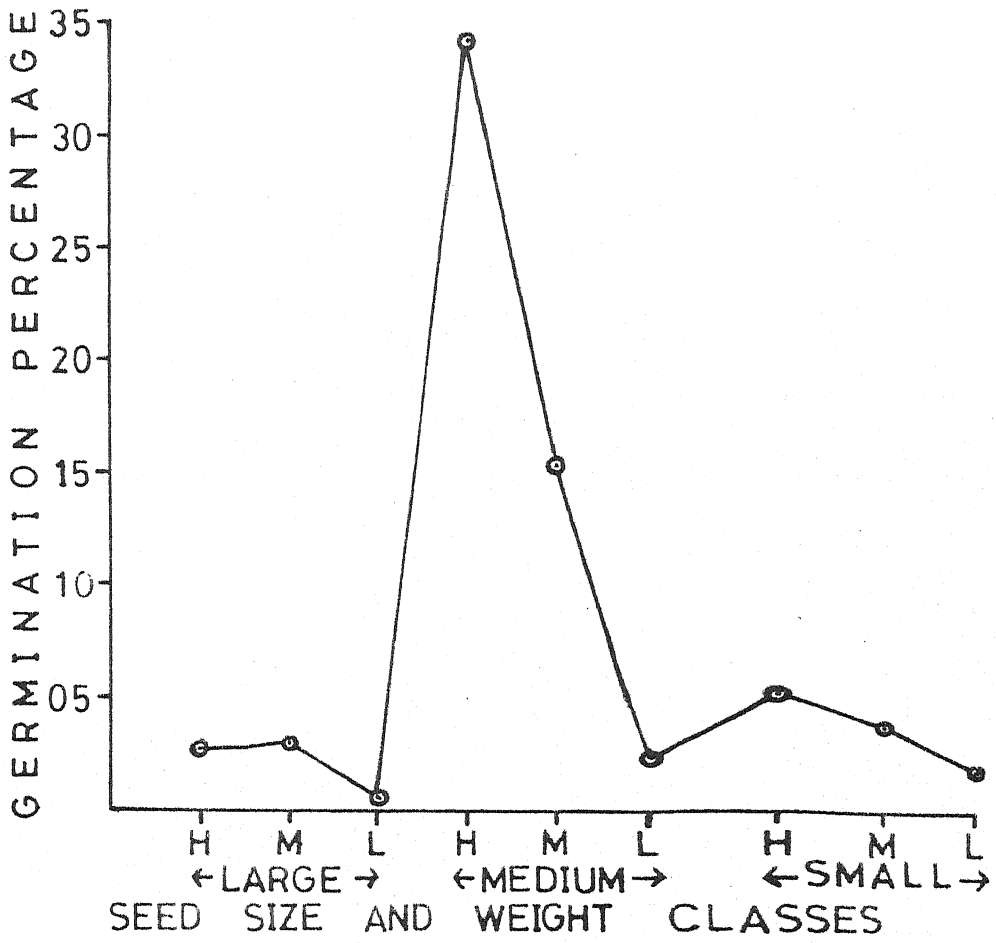


FIG. 5.7A- EFFECT OF SEED SIZE AND SEED WEIGHT ON THE GERMINATION PERCENTAGE OF A. PENDULA SEEDS.

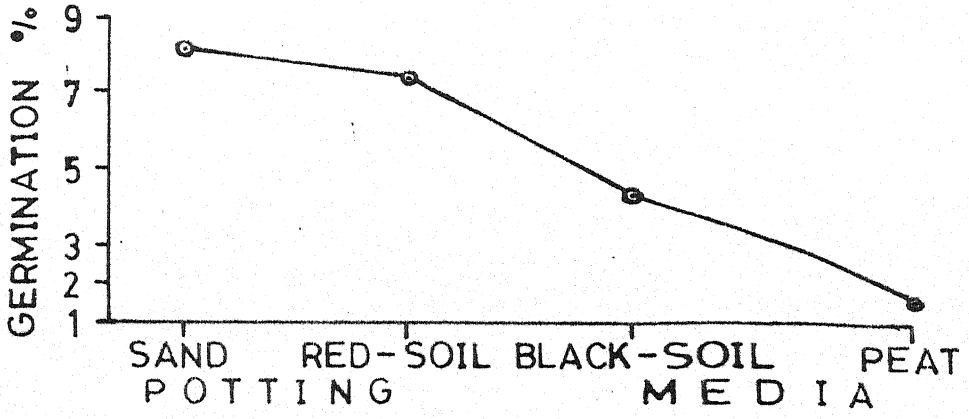


FIG. 5.7B- EFFECT OF FOUR DIFFERENT POTTING MEDIA ON THE GERMINATION PERCENTAGE OF A. PENDULA SEEDS.

TABLE - 5.9 EFFECT OF WEIGHT AND SIZE OF *ANOGEISSUS PENDULA* SEEDS* ON THE GERMINATION PERCENTAGE.

SEED SIZE	SEED WEIGHT		
	HEAVY	MEDIUM	LIGHT
LARGE :			
Av.	2.8	3.0	0.6
S.E.	± 0.84	± 0.68	± 0.36
Max.	4.0	4.0	2.0
Min.	1.0	1.0	0.0
MEDIUM :			
Av.	34.2	15.4	2.4
S.E.	± 1.40	± 0.90	± 0.32
Max.	40.0	19.0	3.0
Min.	26.0	10.0	1.0
SMALL :			
Av.	5.2	3.8	1.8
S.E.	± 1.04	± 0.78	± 0.56
Max.	7.0	5.0	3.0
Min.	3.0	2.0	0.0

* 5 Replicates of 100 seeds each

LEGENDS : Av. : Average, S.E. : Standard error,
Max. : Maximum, Min. : Minimum

respectively, whereas, it was 14.06, 7.4 and 1.6 percent of the total in heavy, medium and the light weighted seeds respectively. A pictorialised scatter diagram of the average (Of five replicates) germination behaviour in each of the nine weight and size class is portrayed in Fig. 5.8.

Regarding the effect of four different potting media on the germination demeanour of A.pendula seeds, Table 5.10 guides to infer that the pure sand as a medium was best suited for germination followed by red soil. 8.2 percent germination was gained in the sand as against 7.4 percent in the red soil. However, both the black soil and the peat have relatively retarding effect on the pattern of seeds germination (Fig.- 5.7b). Black soil as a medium affected only 4.4 percent seeds to germinate, whereas, the peat as a medium was just able to give 1.6 percent of germination. In other words, there was 46.34 and 80.49 percent decrease in the germination of seeds in black soil and the peat respectively in relation to the germination of seeds attained in the sand.

5.5 I N T E R P R E T A T I O N S

REPRODUCTION by seed probably has several important consequences relative to successful establishment and spread of the species. Seed propagation of 'Kardhai' (A.pendula) has been viewed as having only minor importance

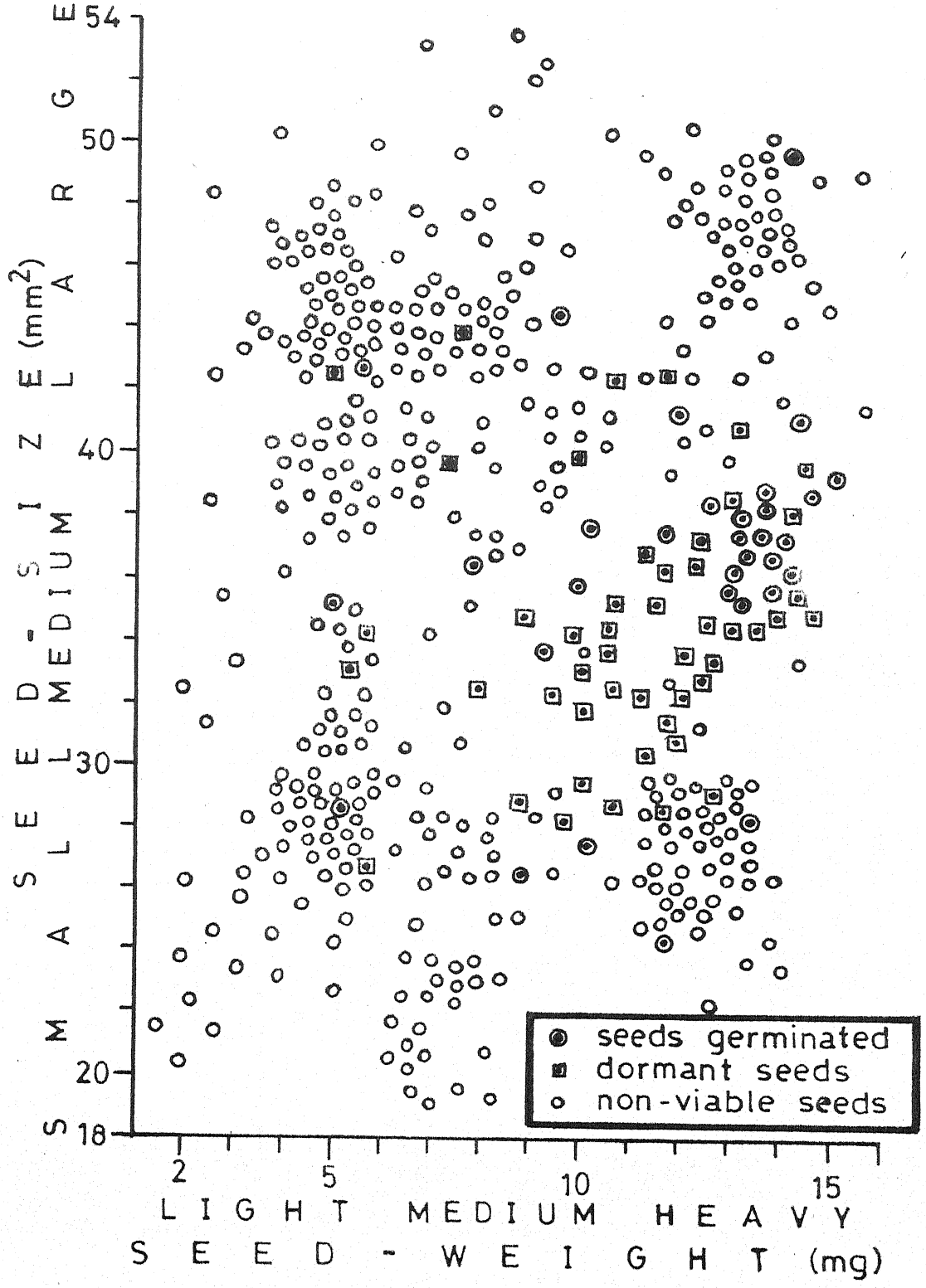


FIG. 5.8 PICTORIALIZED SCATTERED DIAGRAM OF THE AVERAGE GERMINATION IN A. PENDULA SEEDS AS INFLUENCED BY THEIR WEIGHT AND SIZE.

TABLE - 5.10 EFFECT OF FOUR DIFFERENT POTTING MEDIA ON THE GERMINATION PERCENTAGE OF *ANOGEISSUS PENDULA** SEEDS.

CALCULATION HEADS	P O T T I N G M E D I A			
	SAND	RED SOIL	BLACK SOIL	PEAT
Av.	8.2	7.4	4.4	1.6
S.E.	± 1.04	± 0.82	± 0.94	± 0.86
Max.	10.0	9.0	6.0	3.0
Min.	7.0	6.0	3.0	0.0

* 5 Replicates of 100 seeds each

LEGENDS : Av. : Average, S.E. : Standard error,
Max. : Maximum, Min. : Minimum

because the early researches had indicated that the rare seedling establishment was due to the low or non existent germinability[55, 209]. However, au contraire numerous seedlings can be observed in forest. This advises that the 'Kardhai' produces satisfactory viable seeds in nature that have some dormancy.

During observations under different experimental conditions, where the seed failed to germinate or exhibited a low percentage of germination, dormancy and or non-viability of the seed was suspected to be the cause of such germination failure. To overcome this dormancy, and to achieve maximum of germination, a number of pre-treatments were attempted.

A statistical synopsis of the germination studies is presented in Table - 5.11 . The table reveals that a total of 131 treatments were attempted including 8 under control with 5 replicates of 100 seeds each. Thus, 65,500 seeds were placed to germinate and only 5,034 seeds were germinated including three seeds with aberrant seedlings. This indicates that a total of 7.69 % of germination was achieved. Of the 60,500 seeds that were placed in the petri-dishes (100 seeds/dish) on top of the double blotters for various studies only 4,764 seeds germinated suggesting 7.87% of germination in it. Similarly, out of 5,000 seeds which were placed on top of the soil in nursery beds and also in trays, only 270 seeds were

TABLE - 5.11 STATISTICAL SYNOPSIS OF THE GERMINATION STUDIES ON ANOGEISSUS PENDULA SEEDS.

S.No.	SUBSTRATUM FOR GERMINATION	EXPERIMENT NUMBER*	NUMBERS OF TREATMENTS**	NUMBER OF SEEDS USED	NUMBER OF SEEDS GERMINATED	PERCENTAGE OF GERMINATION
1	PETRIDISH	5.1	6	3000	197	6.57
2.		5.2	19 (1)	9500	811	8.54
3.		5.3	11 (1)	5500	536	9.75
4.		5.4	9 (1)	4500	309	6.87
5.		5.5	3	1500	114	7.60
6.		5.6	6 (1)	3000	78	2.60
7.		5.7 (a)	17 (1)	8500	760	8.94
8.		5.7 (b)	17 (1)	8500	672	7.91
9.		5.8 (a)	13 (1)	6500	515	7.92
10.		5.8 (b)	11 (1)	5500	426	7.75
11.		5.9	9	4500	346	7.69
	TOTAL		121 (8)	60500	4764	7.87
12.	SOIL	5.1	6	3000	162	5.40
13.		5.10	4	2000	108	5.40
	TOTAL		10	5000	270	5.40
	GRAND TOTAL		131 (8)	65500	5034	7.69

* As per method described in the text.

** Including control

Values in the parenthesis are numbers of control - sets in the said experiment.

recorded to germinate. This proposed 5.4% of germination.

Interestingly enough, ad val., the germination varied from a total 9.75% in the experiment conducted to study the effect of dry and wet pre-heat treatments (40°C) to a total of 2.60% in the experiment performed to study the effect of sulphuric acid treatments. Treatment-wise the variations in the germination percentage were very great, ranging from maximum 54.2% attained by the medium sized-heavy weighted seeds (Table - 5.9) to mere 0.2% in both, the hot water treatment for 5 minutes duration in aqua bulliens (Table - 5.4) and the sulphuric acid treatment for 5 minutes duration (Table - 5.6). Replicate-wise, a maximum of 40% germination was recorded in one of the replicate containing medium sized-heavy weighted seeds (Table - 5.9) and a minimum of zero percent germination was recorded in some of the replicates placed under four different experiments viz., (1) - Hot water treatment for both, 1 minute and 5 minutes durations in aqua bulliens (Table - 5.4), (2) - Sulphuric acid treatment for 2, 5 and 10 minutes durations (Table - 5.6), (3) - Seed weight and size effect : in two of the nine classes i.e., large sized-light weighted and the small sized-light weighted seeds (Table - 5.9) and (4) - Impression of the potting media : in peat (Table - 5.10). A diagrammatic representation of the statistical synopsis of germination studies is equipped in Fig.- 5.9 .

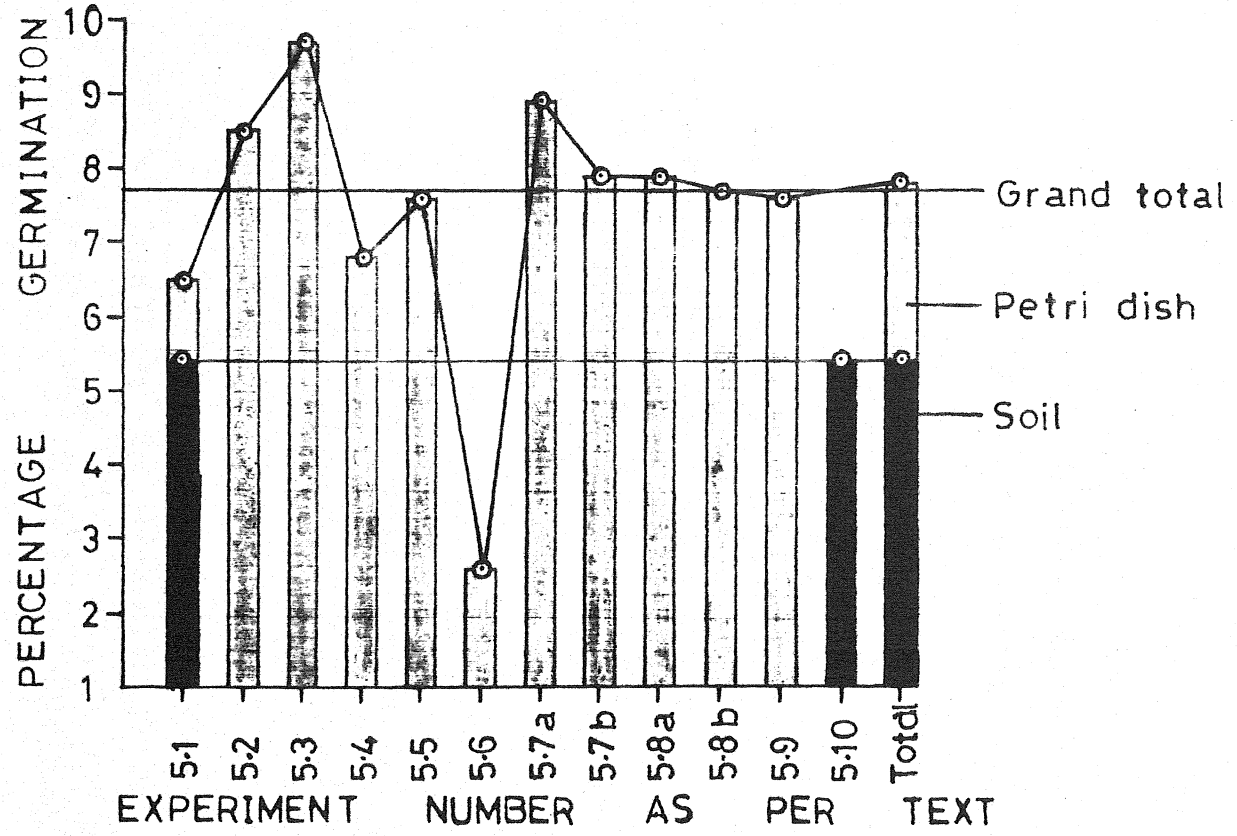


FIG. 5.9 STATISTICAL SYNOPSIS OF SEED GERMINATION STUDIES IN A. PENDULA UNDER VARIOUS EXPERIMENTAL TRIALS.

The determination of seed sources which are most suitable for different geographical area is one of the highly urgent need in the silviculture of tropical and sub-tropical species. Silviculturists, tree-physiologists, tree-geneticists and the tree-breeders all have to select from among the provenances, those which are best adapted to genetic variation between seed sources in relation to the climatic conditions. Genetic variations can be determined only if quantitative and or qualitative differences can be detected between populations or the individuals. The germination phase offers particular advantage for measuring differences between the provenances. One advantage is that it is relatively easy to ensure that the germinating seeds are exposed to an approximately uniform condition.

A non avis, the difference in the percentage germination of A.pendula seeds in relation to their sites may be due to the fact that the viability percentage of those seeds might have changed with the changes in topographic, edaphic and the climatic conditions. The germination percentage decreased from site-II to Site-IV in the following secundum ordinem : S-II > S-V > S-VI > S-III > S-I > S-IV. The topography was generally undulating in Bangawa (S-I), Laxmanpura (S-III) and Simravari (S-IV). Secondly, variation in the amount of moisture present and the water holding capacity of A.pendula

seeds in relation to sites were mainly responsible for differences in their germination percentage. The turgidity of the acquired seeds can also be held responsible, since the increase in turgidity of A.pendula seeds invariably decreased the germination percentage. Differences in the microclimatic conditions such as atmospheric humidity nutrient status of the soil, light intensity, temperature and in the biotic disturbance in these sites might be the other reasons for the differences in the germination percentage of seeds.

Physically dormant seeds are known to respond favourably only by some kind of physical pre-treatments [40, 4-48]; among forest trees, this type of dormancy is observed in seeds of some leguminous species[231, 303, 304], and in some species of the families Anacardiaceae, Ericaceae, Rhamnaceae, Sapindaceae and Sapotaceae etc.[62]. Mechanical scarification or treatment with sulphuric acid[44, 45, 156], or with hot water[62] is used to overcome the dormancy of these seeds.

Seed-coats have long been considered to be a kind of barrier to water absorption. Once the coat is made permeable, germination of most species proceeds under a favourable environment. In the present investigations, seed-coats of A.pendula doesn't seem to impose any dormancy or to inhibit water absorption seriously. A comparatively better response of germination in soaked seeds in a very short duration of the time (Table - 5.2, 5.3 and 5.4) and poor or

negligible response in sulphuric acid treatments (Table - 5.6), firmly indicates that in A.pendula seeds the dormancy is not imposed at all by the seed-coat. Secondly, sulphuric acids might have resulted in damaged embryos or have imposed a state of secondary dormancy by making way inside easily through the coats that has resulted in a very poor say almost nil germination.

In the present investigations, it appears that the seeds of A.pendula were sensitive to both, the moisture and the temperature. Such an interacting complex for germination, though interesting, is not probably new to literature, since many of the species have shown to be affected by keeping their seeds at a particular temperature for germination. Also, holding pre-imbibed seeds at a particular temperature has been found to markedly improve the germinability of seeds[444]. Thus, it may be suggested that imbibition of seeds triggers a particular metabolic sequence that is further amplified by temperature.

During imbibition, the seed develops the metabolic systems necessary for growth and the enzymic components of these systems. Enzymes may arise from two sources : they may be released or activated from existing proteins, or they may be synthesized de novo through the nucleic acid-directed protein-synthesis[209].

One of the biochemical findings suggest that temperature in the presence of adequate moisture has a stimulating effect on the mitochondrial metabolism within tolerated limits which is specific in every species[160]. Beyond a certain limit a fall in temperature may inhibit the catabolic activities in seeds that require a comparatively warmer temperature to germinate. It may also result in failure of activation of pre-existing enzymes resulting in germination failure. This might be one of the motives for reduction in germination percentage of A.pgndula seeds when soaked at 5°C temperature (Table - 5.2). Excessively high temperature on the other hand may inactivates some enzymes and denature proteins, thus, upsetting the anabolic activities for the development of the embryonic plant. Hence, there was germination as low as 0.2 percent in aqua bulliens (Table - 5.4).

Temperature regimes regulate synchrony of processes in seeds by effecting on the reaction rates and changes in the physical state of cellular components. In seeds, temperature influences integration of partial processes for germination. Therefore, a generally promotive effect of high temperature (50°C) was noticed as compared to a very high (70°C and 100°C) or low (5°C) temperature in A.pgndula seeds. This serves to make know a selection for mechanisms preventing germination in nature immediately after their shedding during the mid or the late period of winter season.

The results of the experiment on dry and wet heat treatment of seeds prior to placing them to germinate guides, that a minimum duration of two days were most effective in enhancing the germination percentage of the soaked seeds of A.pendula. Au contraire, the unsoaked seeds displayed that a minimum of five days time was most effective in attaining the maximum germination of the seeds. These findings are in accordance with the facts that in arid and semi-arid regions the forest-floor, on which most of the seeds are disseminated, faces prevailing high temp., in summer and sufficiently low temperature in winter. Generally these seeds germinate at the onset of rains just after passing an intensely hot and comparatively dry summer period. Hence, in the laboratory conditions, a pre-treatment of seeds at comparatively high temperature than that of range seems to be beneficial in initiating most of the seeds of A.pendula to germinate. The present investigation specifies that the seed-bed temperature should be given proper consideration in the production of seedlings of A.pendula, both, in the nursery and in the field.

The wide range of temperature tolerance of 'Kardhai' seeds potentially favour large number of seedling starts. However, progressively the higher temperature becomes increasingly detrimental; lower temperature near freezing is depressing, but not permanently so since some of the seeds were still able to break seed-coat and sprout. Air temperature

of 45°C are occasionally reached on sites during scorching summer. However, direct solar insolation on a soil surface and other characteristics of a microsite may result in temperatures well above the atmospheric and would represent a limitation to the seedling establishment.

Light is one of the important factors affecting seed germination . Since the middle of the last century, the role of light and darkness in germination has been discussed in a great number of review articles[92, 115, 116, 156, 192, 193, 444]. In the present investigation, the germination, though low, indicates that A.pendula seeds can germinate in both, the light and the dark condition i.e., in cleared and in uncleared bushes and thickets in Nature. On the basis of the classical concepts[92, 115], it also suggest that these seeds are photo-indifferent. However, the fact that there was slight and significantly greater germination in the diffused light conditions than in the dark and the full light, support the field observations in that there is noticeable increased number of seedlings in the shaded area under vegetal cover.

A fairly better response of A.pendula germination due to pre-treatment with the growth substances particularly IBA and GA suggest several options. One of the most important factors in the seed germination is the relative availability and activity of the growth substances. The breaking of seed

dormancy may be interpreted as a result of the growth substances regulating growth of the embryo. Another interpretation is that the chain of reactions or processes initiated by some internal and or external facors are bypassed by the application of growth hormones. Or the exogenous application of growth hormones probably compensated for a natural or environmental-induced deficiency.

Auxins are ordinarily not present in dry seeds but are formed ad incunabulis of the germination process[209, 231]. The first auxin formed is probably released from a bound-auxin pool. It seems that in A.pendula seeds bound-auxin pool might be deficient and an exogenous application of this in form of IBA compensates the deficiency which in turn regulates and stimulates further stages of the germination process and ultimately result in a better response of sprouting.

It is an established fact that one plant may influence the germination, growth and the metabolism of other plant through the release of chemicals which may be harmful or beneficial. This has been referred to as 'allelopathic effect'[344]. In the present findings, leachates of A.catechu, A.nilotica and H.ciliaris have harmful effects on the mode of germination in A.pendula seeds and the effect is increased with the simultaneous increase in the conc. On the other hand, leachates of A.pendula (self-compatability), H.monosperma,

H.integrifolia and A.repens have a beneficial effect and that too lower level of their concentrations. only at the

It is considered that A.catechu, A.nilotica and E.ciliaris all contains some chemical inhibitors falling under the group 'secondary compound'. Presumably these are abscisic acid, glycoside, juglone (Quinones), phenolics or some cynogenic compounds. These compounds play some role in the dormancy or delayed germination of A.pendula seeds. These substances may inhibit the gibberellin-stimulated growth[206] or inhibit the initial metabolic processes leading to decrease in the germination. The range of impact of these inhibitors are scarcely understood or even recognized[209]. Doubt still exist that allelopathic substances exert more than a transient and localized effect on the introduction and persistence of the species in range plant communities, though, it will be ignotum per ignobius.

Moreover, the findings that the inhibitory or the stimulatory processes are produced by some chemicals present in the plant extracts, it is more likely that an embryo is effected. Probably, the physiological activity of embryo in the seed as influenced under suitable dilution of the concerning plant extract, is increased or decreased through the metabolic processes. Consequently, the embryo can resume or retard its active growth, and the germination is effected positively or negatively.

The results of seed size and seed weight influences indicate that medium sized seeds of A.pendula were more viable than the large or the small sized seeds. But comparatively, the viability was high in heavy weighted seeds followed by the medium and the light weighted seeds in a decreasing sequence. Astonishingly enough, the heavy weighted - large sized seeds were very poorly viable. These observations forced to infer that there might be some causes in failure of the seeds to develope completely.

Heavy weighted seeds of A.pendula contained some black, rusted and powder-like substances as observed by cutting these ungerminated seeds. It seems that in such non-viable heavy weighted seeds, fertilization occured and the growth of the embryo proceeded but was arrested, might be at a later stage in its development which usually resulted in the formation of these non-viable heavy weighted seeds.

Similarly, in small sized seeds a bulk of the composition was of the non-viable seeds which were the empty seeds. These observations hinted to presume that there might be a failure of fertilization in such seeds or most probably the fertilisation occurred but abortion followed before the initiation of divisions in the egg.

The variation in the germination response of A.pendula seeds in different potting media could be imputed

in relation to moisture and to the aeration. Due to poor aeration conditions in the black soil and still more poorer in the peat, the seeds of A.pendula displayed poor germination in these two media, whereas, relatively good aeration conditions in the red soil and very good in the sand might have forced many more seeds of 'Kardhai' to germinate.

It is very definitedly known that seed germination is affected by oxygen supply. The pattern of oxygen uptake follows that of water absorption, which suggest that the respiratory process may be closely coupled with the water uptake in the progress of germination. The primary role of oxygen is, of course, as the terminal electron acceptor in catabolism.

When the seed coat accumulates large quantities of water, by sowing them in relatively high conditions of moisture as in the black soil or in the peat, gaseous diffusion is hindered and the germination inhibited. This condition is known as 'water-sensitivity'[234]. This excess water may result in a detrimental incipient germination. Seeds of A.pendula might have to pass through unnecessary soaking in the black soil and in peat, which might have resulted in the growth of micro-organisms resulting in the deterioration of seeds during germination.

Ad finem, it can be documented that these treatments have independent affects, but should be considered reciprocally. It is quite probable that various pathways leading to germination are present in A.pendula seeds, and they are geared to each other. More over, the behavior of seed to the external condition is certainly affected by the internal condition of the seed.

Thus, some interaction appears to be responsible for germination of A.pendula seed with participation from various physical and chemical as well as the biological factors. The ultimate aim of such control mechanism, however, is to achieve survival of the species and long term optimal growth. The success of A.pendula in its specialised habitat might, therefore, be ascribed to its peculiar requirement for a moderately high temperature, sufficient soaking, diffused light condition, good aeration etc.etc.

Even though satisfactory pre-sowing treatments have been worked out for A.pendula seeds, but the exact cause of delayed and retarded germination in the seed is still not known. For centuries man has tended to select agricultural seeds that germinate promptly. The result is that most of our cultivated species are cent-percent viable and non-dormant. A similar approach will probably work with the forest species. But strict control over germination of the

seeds of woody plants can not be attained untill we learn what physiological processes are involved in delayed germination. Then, and perhaps then only we can turn the dormancy off or on as needed with chemicals and or with other methods.

Hitherto, the germination percentage tested in laboratory has not been useful in estimating a field performance. This is because a simple and rather poorly controlled condition has been adopted for testing them in spite of the fact that the seeds behaved differently under varied range of conditions. Actually, the germination behaviour of seeds of A.pendula has not been studied in detail under the combined condition of temperature, light, moisture etc., due to the lack of facilities. At present the controlling techniques in relation to these external factors affecting growth are advancing and a number of controlled conditions are available. If experimental data are collected under many controlled conditions according to a careful planning, the laboratory germination percentage may have a high reproducibility and be a reasonable indicator in estimating nursery germination percentage in the light of meteriological data. A series of experiments reported here are just an approach to this purpose.

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C H A P T E R - VI

G R O W T H P E R F O R M A N C E

C H A P T E R - VI

G R O W T H P E R F O R M A N C E S

6.1 P R E M I S E

GROWTH in unicellular organism is complicated enough, involving the processes of cell division, enlargement and cell organelle production, but with the evolution of the multicellular higher plants, the phenomenon of growth has become enormously complicated[209]. Growth is an essential character of life or of living organism and is by far the most complex of all the physiological processes[233].

The rate of growth varies vastly with different species of plants and with the same species under unlike environmental conditions. Regardless of the habitat in which it is growing, whether a green-house, cultivated field, forest, mountain top or bottom of the lake, a plant is incessantly subjected to the variabilities of a complex and more or less interdependent set of environmental factors.

The conditions that prevail very close to

the ground is of considerable significance, since a plant is very sensitive to climate in its formative years[324]. The major environmental inputs that impulse terrestrial systems include solar radiation, temperature, water and nutrients. Coupled with these environmental constraints are the plant's own internal regulators, whose control is modified according to the environmental conditions.

Driven by economic expedience agriculturists modify the environment to achieve optimum crop performance. They relieve limitations on plant growth and so maximise yields (atleast within the genetic limitations of crop)[209].

While defining growth, two aspects - a permanent change in size and an increase in dry weight, appear quite reasonable to consider. When growth occurs, plant organs increase in size and in dry weight. Both these aspects together provide a prelude to understand growth. However, growth can be defined as, "A vital process which brings about a permanent change in any plant or its part in respect to its size, form, weight and volume". Thus growth is the increase in size and

dry weight of a plant, or cell, which cannot be reversed. However, it does not include the increase in size due to the uptake of water.

6.2 REVIEW OF LITERATURE

A comprehensive review of all the studies carried out in India upto 1981 in the field of 'FOREST INFLUENCES' presents the present status of research on environmental affects of forests[130]. Recently, all the results of microclimatic studies conducted during the last twenty five years in plantations and in natural forests at Dehradun has been reviewed[100]. Current advances in forest microclimate research in India has also been provided in an article[434]. Similarly, the literary compositions in journals about the dry matter productions in seedlings, as influenced by the environmental factors are also available[205, 246, 247].

One of the most important contribution of the nineteenth century experimental plant physiology to agriculture was the discovery that soil fertility and crop yields can be increased by adding inorganic nutrients to soils which was an improvement over the common method of the use of plant and animal debris.

Since than researches on various aspects of inorganic fertilizers were carried out and are too numerous to be listed[2, 3, 9, 10, 11, 46, 55, 94, 135, 141, 187, 265, 274, 300, 318, 319, 333, 406, 407, 408, 413, 420, 501].

The fertilizers are added to soil to provide proper nourishment to the plant in order to fully utilize its genetic potentials. Nitrogen is required in large quantities by almost all the plants[132]. Phosphorus and potassium are other two of the three major plant nutrients which govern the overall growth of any species[53, 332, 336, 499].

From the standpoint of mineral nutrition, nitrogen more commonly appears to be the growth limiting factor than any other macronutrient in Pinus caribaea seedlings while potassium plays an important role in activating enzymes involved in wide range of processes including starch and protein synthesis[9, 10]. Nitrogen application increased the biomass in most of the species in a dry grassland, where its principal affect was to magnify the results of different watering treatments[207]. Experiments with one year old seedlings of Cinchona ledgeriana reports that potassium (20kg/ha)

induced branch formation and circumference of the stem, whereas, the nitrogen at both, low and the high levels augmented the alkaloid formation and extension in growth significantly. A reduction in branch formation was noticed in treatments with phosphorus fertilisers[274]. The application of N, P and K resulted in better growth and the biomass production of Eucalyptus grandis plantation[318, 319]. In Eucalyptus tereticornis, the dry matter production as well as phosphorus uptake increased with the age and time. Leaves retained the maximum of phosphorus followed by stem and the roots in descending series[406]. Fertilisation with nitrogen increased the size of winter annuals in the Mojave desert, but phosphorus did not[491]. In other studies, preplant application of nitrogen in form of urea was found to be detrimental for the survival of teak. Application of phospherus, however, does not affected the seedling establishment[141]. In Solanum khasianum application of nitrogen has not exhibited any significant affect on the plant height[149].

In recent years, the plant hormones have attracted much attention for their expressive role in growth and the development of plants. They play a major

part in controlling different phases of plant life including shoot and root growth[352, 432], and dormancy [355, 468, 480]. Internal differentiation of plants, initiation of cambial activiy[56], xylem differentiation, annual ring formation, holocellulose production and mineral uptake[438] etc., are also considered to be under the influence of hormones.

In looking back over the many heterogeneous affects of hormones on growth and development of plants, it is evident that the variety and the range of responses elicited by these substances are unique. In much of the work with hormones great divereity in type of response has been observed. The response obtained frequently depended on many factors, such as the kind or variety of plants used, the part of the plant treated and its stage of development; the amount of hormone absorbed and the kind of hormone applied.

Conceptually, a hormone is a chemical regulator, which acts as a messenger. In plants this chemical messenger is known as 'PHYTO-HORMONES'. Five classes of phytohormones are well established viz., :

(a). The auxins and

(b). The gibberellins, both of which stimulate cell elongation;

(c). The cytokinins, which stimulate cell divisions;

(d). The ethylene gas, which stimulates the swelling or isodiametric growth of stems and roots; and

(e). The abscisic acid. The others await their discovery or elevation to the hormonal status[209].

The application of IAA (Indole Acetic Acid) for inducing seedling growth has been reported by numerous workers[19, 134, 390, 402]. The stimulatory effect of externally applied IAA varied with the concentrations in Dendrocalamus strictus and Tectona grandis[245]. Higher conc., of IAA are responsible for inhibitory effects on primary root elongation[440]. Gibberellic acid (GA) has been successfully used to induce extension growth in some forest species[271; 272]. It induced faster seedling growth and other related processes in several plants[65, 236, 276, 377]. There is possibility to increase growth of teak seedlings to transplantable size in the same growing season by judicious application of GA and other nutrients[236]. The application of higher conc., of GA resulted in decreased

growth in a descending order culminating in suppression at 100 ppm in both Tectona grandis and Dendrocalamus strictus[244].

The seed sowing techniques have attracted much attention in the recent years, for their role in optimum recovery and in vigorous production of the planting stock. Notable contributions has been made desirously to make the most economical use of nursery space[34, 42, 241, 297, 409, 410, 411]. The biomass accumulation pattern differs in plant part as well as in different spacings with similar deviations in the average height and the diameter. Biomass of Leucaena leucocephala was found to be maximum in the spacement of 1.25 x 1.25 m out of the four different spacings. The mean annual increment (MAI) was also maximum in the same spacing[241]. Cymbopogon martinii var. motia produced essential oil of good quality with plant densities (spacing treatments) of 14.81 and 22.22/m^2 and gave an estimated oil yields of 152.1 and 154.2 litres/ha respectively[297].

In a forest ecosystem vegetation, climate and the soil exist in intimate dynamic relationship. Growth and distribution of different species is the resultant affect of interaction of climate and the soil[256]. Soil

factors have the overriding importance for they could be manipulated to produce higher yields[396]. The growth and the quality of forests, whether naturally occurring or artificially created, depends basically on the physical and the nutrient status of the soil. Work on seedling establishment, survival and soil characteristics in relation to seedling growth is scarce except some experiments by Troup[458]. Studies of similar nature on other species reveal that such investigations are useful in nursery practices and ultimately in raising plantations[54, 108, 255, 378, 449, 496].

The health and vigour of the entire plant is conditioned by the distribution and the activity of its roots. Soil texture is more important for proper growth of the root[350]. Healtheir seedlings of Albizia amara could be obtained by using red soil rather than mixed or the black soil. The texture of red soil coupled with its high permeability was found to promote growth of root system and nodulation resulting in better seedlings[348]. A progresseive retardation in growth of Pinus caribaea seedlings was found due to poor aeration caused by the high clay content of the soil and its poor nutrient status as compared with peat[23]. Soil properties viz.,

organic matter content, pH, texture and the microclimate were related to early height growth of Pinus banksiana, P.resinosa, Picea glauca and hybrid larch (Larix leptolepis x L.deciduas)[341].

The nursery acquired shoot and root habits of loblolly (Pinus taeda) and short leaf (P.echinata) pine seedlings were modified by soil texture and moisture after their transplantation[431]. The importance and need of soil evaluation in relation to timber production has been emphasised in many reports. Sixty percent increase in the timber production has been observed by matching the species with the soil[430]. Data on growth pattern of vegetation and regeneration status of moist deciduous forests of Doon valley (with or without Shorea robusta) suggest that the organic matter, moisture regime and the texture are most important influential soil factors in deciding the growth quality and regeneration of these forests[415].

Seed size and seed weight are important characteristics associated with seedling vigour. It has been found that many vegetative species almost invariably produce larger seedlings when grown from the larger seeds. [159], small seeds have often been found to give poor plant

establishment in field, whereas, the larger seeds the best. Differences in seed size and weight within a seed sample are reflected in the seedling size in wide range of plants[152].

A strong relationship of seed weight with several growth factors has been suggested in the early development of Pinus coccarpa seedlings[174]. Seed weight was also found to be the most important factor affecting the size of one year old eastern white pine (Pinus strobus) seedlings. The heavy seeds germinated early, fastly and the resultant seedlings survived in a large proportions than the light seeds[305] However, in Albizia lebbek the smaller seeds produced the healthiest seedlings as compared to the large and the heavy seeds[304] This type of behaviour has been observed in case of several field crops[494].

6.3 M A T E R I A L A N D M E T H O D

FOR growth performance studies, Anogeissus pendula seeds were culled from the parent trees of 50 - 75 cm gbh class as recommended[456]. A composit sample of seeds gathered from all the six forest blocks was used. The experiments were conducted in U.P.State Govt.

Forest Nursery at Bangawa, Jhansi.

6.3(a) R A I S I N G O F T H E S E E D L I N G S

IN order to raise seedlings, seeds of A.pendula were uniformly sown in 1 m X 10 m sized nursery beds. The sowing was done in the month of April, 1986. Beds were irrigated profusely per diem using adjacent river water. In July, 1986, when the seedlings were nearly three months old, they were very carefully transplanted in the perforated polythene bags of 6" x 12" size. For transplanting, approximately uniform sized seedlings were considered. Initially two seedlings were maintained in each of the polythene bags. These bags were placed in the sunken-beds and were regularly irrigated through channel using the same river water.

6.3(b) I N D I C E S O F G R O W T H

GROWTH is affected by a number of factors both environmental and the physiological. It has been desired very often, to provide some sort of qualitative expression to the amount of growth which has been accomplished by a plant or a group of plants during various treatments in a given period of time. The principal indices, that has been employed for this purpose, are <u>at infra</u> :

(1). Increase in length of stem and the root;

(2). Increase in photosynthetic area;

(3). Increase in number and total length of the secondary-roots;

(4). Increase in girth of the seedling-collar;

(5). The fresh weight increment; and

(6). The dry weight increment etc.

6.3(c) G R O W T H D Y N A M I C S

ALTHOUGH species vary enormously in their assimilative abilities, growth controls inherent in the plant still exert powerful effects over their general performance. Physical inputs sustain growth, but biological regulation dictates the pattern of its utilisation and ultimate expression. If we are to understand the nature of this regulation at a whole-plant level and appreciate the interactions between plants and their environment, we need more detailed measurements than simply the final yield. Growth analysis and the mathematical models of growth and development provide such parameters.

V.H.Blackman[60] used the term 'EFFICIENCY INDEX' to denote the compound interest law of plant

growth. It has now found wide acceptance as Relative growth rate (RGR). After Blackman's efficiency-index, four concepts were developed for use in growth analysis[113 136, 137, 289, 290, 486, 487, 492].

(1). Relative Growth Rate (RGR) : It is the increase in weight per unit of original weight over a given interval of time.

$$RGR = \frac{\ln (W_2/W_1)}{t_2 - t_1}$$

where, W_1 and W_2 refer to whole plant dry weight on two successive occasions t_1 and t_2. In represents the neoparian log.

(2). Leaf Area Ratio (LAR) : It is the ratio of leaf area to whole plant dry weight.

$$LAR\ (A) = \frac{L}{W}$$

where, L represent leaf area and W the whole plant dry weight.

$$MeanLAR(F) = \frac{L_1 + L_2}{W_1 + W_2} \times \frac{1}{2}$$

(3). Net Assimilation Rate (NAR) : It is the rate of increase in dry weight per unit leaf area, assuming that both dry weight and leaf area are increasing exponentially. Photosynthetic tissues other than leaves would of course be taken into account.

$$\text{NAR } (E) = \frac{W_2 - W_1}{L_2 - L_1} \text{ in } \frac{L_2/L_1}{t_2 - t_1}$$

(4). Relative Leaf Growth Rate (RLGR) : It is analogous to relative growth rate of the whole plant.

$$\text{RLGR } (R_L) = \text{In } L_2 - \text{In } L_1$$

If leaf area and dry weight are both increasing exponentially, the following relationships can be derived :

$$R = AE$$

Growth in a higher plant is obviously a complex phenomenon, and a simple mathematical formulation can do little more than embody some of the factors dictating plant performance. Even then, the concepts of growth analysis have proved highly effective in studying a plant's reaction to many environmental conditions.

6.3(d) E X P E R I M E N T A L D E S I G N S

DURING present investigations, the experimental studies were conducted in order to understand the affects of some factors and to arrive at some conclusions regarding performances of growth in Anogeissus pendula seedlings. The experiments designed for the purpose were ut infra :

(1). Inorganic fertilizers,

(2). Growth hormones,

(3). Seed size and weight,

(4). Soil compositions, and

(5). Density.

All these ut supra trials were initiated simultaneously in the month of August, 1986. The initial growth measurements of the seedlings (10 replicates) were recorded just before launching the experiments.

Study was conducted in randomised block design replicated five times. Seedlings under each treatments were harvested after 12 months (August, 1987), at which time the experiments were terminated, and were immediately and very carefully transported to the Laboratory (Bipin Bihari College, Jhansi) for making

further studies. Data for growth under various parameters including fresh and dry matters were measured and recorded.

6.3(d)-i I N O R G A N I C F E R T I L I Z E R S

The experiment was conducted for 12 months (Aug., 1986 to Aug., 1987) for studying the effects of different levels of inorganic fertilizers (N, P and K) on the growth performances of A.pendula seedlings. The treatments consisted of various combinations of four levels of nitrogen (0, 40, 80 and 120 kg/ha) and three levels of both phosphorus and potash each (0, 20 and 40 kg/ha). The three fertilizers were used in forms of Ammonium nitrate (NH_4NO_3), Sodium hydrogen phosphate ($NaH_2PO_4.2H_2O$) and Potassium sulphate (K_2SO_4). The combinations used for treatments, in various proportions of the three fertilizers including control, are listed in Table - 6.1. One third of the total fertilizer combination was applied as a basal dose while initiating the experiment and the remaining two third dose was top-dressed in two splits each at an interval of four months i.e., in Dec., 1986 and April, 1987.

6.3(d)-ii G R O W T H H O R M O N E S

Raised and transplanted seedlings in polythene bags were used for the experiment. Aqueous solutions of

TABLE - 6.1 VARIOUS COMPOSITIONS EACH WITH A TREATMENT NUMBER OF FERTILIZER, SOIL COMBINATIONS, GROWTH HORMONES, SEED WEIGHT AND SIZE CLASSES, AND DENSITIES USED DURING THE GROWTH AND THE DRY MATTER PRODUCTION STUDIES OF ANOGEISSUS PENDULA SEEDLINGS.

S.No.	FERTILIZERS		SOIL MIXTURES		HORMONES		SEED TYPES		DENSITIES	
	I	II	I	II	I	II	I	II	I	II
1.	F - 1	$N_0P_0K_0$	S - 1	$A_4B_0C_0D_0$	H - 1	IAA - 10	W - 1	ML	D - 1	400
2.	F - 2	$N_0P_0K_1$	S - 2	$A_3B_1C_0D_0$	H - 2	IAA - 100	W - 2	MM	D - 2	200
3.	F - 3	$N_0P_0K_2$	S - 3	$A_3B_0C_1D_0$	H - 3	IAA - 500	W - 3	MS	D - 3	100
4.	F - 4	$N_0P_1K_0$	S - 4	$A_3B_0C_0D_1$	H - 4	IBA - 10	W - 4	ML	D - 4	50
5.	F - 5	$N_0P_1K_1$	S - 5	$A_2B_2C_0D_0$	H - 5	IBA - 100	W - 5	MM	D - 5	25
6.	F - 6	$N_0P_1K_2$	S - 6	$A_2B_0C_2D_0$	H - 6	IBA - 500	W - 6	MS	D - 6	16
7.	F - 7	$N_0P_2K_0$	S - 7	$A_2B_0C_0D_2$	H - 7	IPA - 10	W - 7	LL	D - 7	10
8.	F - 8	$N_0P_2K_1$	S - 8	$A_2B_1C_1D_0$	H - 8	IPA - 100	W - 8	LM		
9.	F - 9	$N_0P_2K_2$	S - 9	$A_2B_1C_0D_1$	H - 9	IPA - 500	W - 9	LS		
10.	F - 10	$N_1P_0K_0$	S - 10	$A_2B_0C_1D_1$	H - 10	GA - 10				
11.	F - 11	$N_1P_0K_1$	S - 11	$A_0B_4C_0D_0$	H - 11	GA - 100				
12.	F - 12	$N_1P_0K_2$	S - 12	$A_1B_3C_0D_0$	H - 12	GA - 500				
13.	F - 13	$N_1P_1K_0$	S - 13	$A_0B_3C_1D_0$	H - 13	KN - 10				
14.	F - 14	$N_1P_1K_1$	S - 14	$A_0B_3C_0D_1$	H - 14	KN - 100				
15.	F - 15	$N_1P_1K_2$	S - 15	$A_0B_2C_2D_0$	H - 15	KN - 500				

(Continue)

16.	F - 16	$N_1P_2K_0$	S - 16	$A_0B_2C_0D_2$	H - 16	MH - 10
17.	F - 17	$N_1P_2K_1$	S - 17	$A_1B_2C_1D_0$	H - 17	MH - 100
18.	F - 18	$N_1P_2K_2$	S - 18	$A_1B_2C_0D_1$	H - 18	MH - 500
19.	F - 19	$N_2P_0K_0$	S - 19	$A_0B_2C_1D_1$	H - 19	COU - 10
20.	F - 20	$N_2P_0K_1$	S - 20	$A_0B_0C_4D_0$	H - 20	COU - 100
21.	F - 21	$N_2P_0K_2$	S - 21	$A_1B_0C_3D_0$	H - 21	COU - 500
22.	F - 22	$N_2P_1K_0$	S - 22	$A_0B_1C_3D_0$	H - 22	Cont. - d.w.
23.	F - 23	$N_2P_1K_1$	S - 23	$A_0B_0C_3D_1$		
24.	F - 24	$N_2P_1K_2$	S - 24	$A_1B_1C_2D_0$		
25.	F - 25	$N_2P_2K_0$	S - 25	$A_1B_0C_2D_1$		
26.	F - 26	$N_2P_2K_1$	S - 26	$A_0B_1C_2D_1$		
27.	F - 27	$N_2P_2K_2$	S - 27	$A_0B_0C_2D_2$		
28.	F - 28	$N_3P_0K_0$	S - 28	$A_0B_0C_0D_4$		
29.	F - 29	$N_3P_0K_1$	S - 29	$A_1B_0C_0D_3$		
30.	F - 30	$N_3P_0K_2$	S - 30	$A_0B_1C_0D_3$		
31.	F - 31	$N_3P_1K_0$	S - 31	$A_0B_0C_1D_3$		
32.	F - 32	$N_3P_1K_1$	S - 32	$A_1B_1C_0D_2$		

(Continue)

33.	F - 33	$N_3P_1K_2$	S - 33	$A_1B_0C_1D_2$
34.	F - 34	$N_3P_2K_0$	S - 34	$A_0B_1C_1D_2$
35.	F - 35	$N_3P_2K_1$	S - 35	$A_1B_1C_1D_1$
36.	F - 36	$N_3P_2K_2$		

LEGENDS :- I : Treatment number, II : Composition

Fertilizers : N_0 = 0 kg N/ha, N_1 = 40 kg N/ha, N_2 = 80 kg N/ha, N_3 = 120 kg N/ha
P_0 = 0 kg P/ha, P_1 = 20 kg P/ha, P_2 = 40 kg P/ha,
K_0 = 0 kg K/ha, K_1 = 20 kg K/ha, K_2 = 40 kg K/ha,

Soil Mixtures : A = Sand, B = Peat, C = Black soil, D = Red soil, 0,1,2,3 and 4 represent 0 %, 25 %, 50 %, 75 %, and 100 % volume/composition respectively

Growth hormones : IAA = Indole acetic acid, IBA = Indole butyric acid, IPA = Indole Propionic acid, GA_3 = Gibbrellic acid, KN = Kinetin, MH = Maleic Hydrazide, and COU = Coumarin, cont. - d.w. = Control in distilled water, 10, 100, and 500 represent concentrations of the hormone in parts per million (ppm)

Seed types : HL = Heavy weight and Large sized, HM = Heavy weight and Medium sized, HS = Heavy weight and Small sized, ML = Medium Large, MM = Medium - Medium, MS = Medium Small, LL = Light Large, LM = Light Medium, LS = Light - Small.

Densities : No. of seedlings planted in per square meter space.

some natural and synthetic growth hormones viz., Indole acetic acid (IAA), Indole butyric acid (IBA), Indole propionic acid (IPA), Gibberellic acid (GA), Kinetin (KN), Maleic Hydrazied (MH) and Coumarin (COU) each at three concentrations of 10, 100 and 500 ppm were prepared a fresh, (Table - 6.1). These test-solutions were exogenously applied on the exposed parts of the seedlings with the help of a hand sprayer. Every fortnight, spraying of the freshly prepared aqueous test-solutions, was performed in the evening. Seedlings under control were sprayed every time with distilled water. Thus, in all 24 sprays were provided in 12 months. Harvesting of the seedlings for growth analysis were done after a lapse of 15 days from the day of the last spray.

6.3(d)-iii S E E D S I Z E A N D W E I G H T

Seeds were measured individually in order to separating them in nine different categories of weight and size as already mentioned in the text of Chapter 5.3(b)-ix. In the said experiment the seeds falling under each of the nine categories were sown uniformly in 1 m X 1 m sized separate nursery beds for raising the seedlings. Thinning was done every month, whereas, the weeding operations were carried out regularly at weekly

PLATE - 18. THE EFFECT OF INORGANIC FERTILIZER (POTASSIUM - 40 kg/ha) ON THE GROWTH PERFORMANCE OF ANOGEISSUS PENDULA SEEDLINGS AS COMPARED WITH THE NORMAL SEEDLING IN CONTROL (C).

PLATE - 19. THE GROWTH BEHAVIOUR OF ANOGEISSUS PENDULA SEEDLINGS AS AFFECTED BY NITROGEN - 80 kg + PHOSPHORUS - 20 kg/ha FERTILIZER DOSE AND SIMILIZED WITH THE NORMAL SEEDLING UNDER CONTROL (C).


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intervals. The three months old seedlings were transferred to polythene bags. Under each category of size and weight, seedlings of approximately uniform size were considered for transplanting them. After a month of transplantation in polythene bags, initial measurements on growth (10 randomly selected seedlings of each category) were recorded (August, 1986). Finally, the seedlings under each of the nine size and weight classes (Table-6.1) were harvested in the month of August 1987 for determining their average growth and dry matter production.

6.3(d)-iv S O I L C O M P O S I T I O N S

Four soil types Viz., sand, black soil, red soil and peat were considered in the experiment after sieveing them a fond through I.S.S. mesh number 200. These four soil types were mixed in different volume proportions. Thus, in all 35 soil compositions were prepared (Table - 6.1). Each of the 35 potting mixtures were filled in perforated polythene bags of 6" x 12" size. Three months old raised seedlings were transferred in these polythene bags for studying the affects of each soil composition on the growth behaviour and biomass accumulation in them.

6.3(d)-v D E N S I T Y

The experiment was performed on raised nursery

beds of 1 m X 10 m size rather than in polythene bags. Thinning operation was carried out in about three months old seedlings (July, 1986) so that seven different categories of spacing viz., 5, 7.1, 10, 14.2, 20, 25 and 31.6 cm from plant to plant were employed in order to obtaining the densities of 400, 200, 100, 50, 25, 16 and 10 per square meter of space respectively (Table- 6.1). Weeding was done regularly at weekly intervals. Finally, seedlings under each spacing trials were harvested (July, 1987) for analysing their average growth performances and dry matter productions.

6.4 O B S E R V A T I O N S

THE growth gains and the biomass benefits, after 12 months of various treatments on A.pendula seedlings are communicated in section (a), (b) and (c) of the Tables - 6.2, 6.3, 6.4, 6.5 and 6.6. The section (a) of all these Tables furnish separately the affects of various combinations (Table - 6.1) of the different treatments viz., Inorganic fertilisers, Growth hormones, Seed weight and seed size, Potting media and the Density, on the number and total length (cm) of secondary roots and the collar girth (cm) of A.pendula seedlings. The section (b) of the

TABLE - 6.2.(a) EFFECT OF VARIOUS COMBINATIONS OF INORGANIC FERTILIZERS (N P & K) ON THE NUMBER AND TOTAL LENGTH (cm) OF SECONDARY ROOTS, AND COLLAR GIRTH (cm) OF *ANOGEISSUS PENDULA* SEEDLINGS*.

TREATMENTS		NUMBER OF SECONDARY ROOTS	LENGTH OF SECONDARY ROOTS	COLLAR CIRCUMFERENCE
F - 1 :	Av.	34.2	85.0	0.72
	S.E.	± 1.56	± 5.96	± 0.06
F - 2 :	Av.	31.6	62.2	0.72
	S.E.	± 1.22	± 3.48	± 0.05
F - 3 :	Av.	32.2	73.2	0.74
	S.E.	± 1.98	± 2.94	± 0.06
F - 4 :	Av.	45.2	85.6	0.74
	S.E.	± 1.44	± 4.62	± 0.06
F - 5 :	Av.	43.6	94.8	0.76
	S.E.	± 2.36	± 3.38	± 0.07
F - 6 :	Av.	43.2	91.6	0.76
	S.E.	± 2.24	± 4.44	± 0.06
F - 7 :	Av.	45.6	81.4	0.74
	S.E.	± 3.02	± 3.98	± 0.07
F - 8 :	Av.	44.8	93.8	0.68
	S.E.	± 4.24	± 3.64	± 0.04
F - 9 :	Av.	44.0	84.0	0.68
	S.E.	± 2.98	± 3.82	± 0.06
F - 10 :	Av.	33.6	76.0	0.70
	S.E.	± 2.86	± 4.92	± 0.06
F - 11 :	Av.	29.8	88.0	0.74
	S.E.	± 2.16	± 3.16	± 0.08
F - 12 :	Av.	31.0	78.8	0.74
	S.E.	± 1.38	± 2.88	± 0.06
F - 13 :	Av.	36.8	86.6	0.70
	S.E.	± 2.54	± 4.66	± 0.04
F - 14 :	Av.	41.2	92.4	0.74
	S.E.	± 2.96	± 3.98	± 0.06
F - 15 :	Av.	42.0	89.8	0.74
	S.E.	± 2.12	± 5.48	± 0.06

(Continue)

Continued) (11)

F - 16 :	Av.	42.4	93.2	0.72
	S.E.	± 2.34	± 4.34	± 0.07
F - 17 :	Av.	42.6	88.0	0.78
	S.E.	± 3.12	± 2.86	± 0.06
F - 18 :	Av.	43.0	86.2	0.76
	S.E.	± 2.08	± 3.68	± 0.06
F - 19 :	Av.	33.2	77.8	0.74
	S.E.	± 2.56	± 3.48	± 0.07
F - 20 :	Av.	27.8	65.6	0.70
	S.E.	± 2.94	± 3.88	± 0.06
F - 21 :	Av.	30.4	74.2	0.76
	S.E.	± 2.18	± 4.56	± 0.06
F - 22 :	Av.	35.2	70.4	0.74
	S.E.	± 2.98	± 3.84	± 0.06
F - 23 :	Av.	40.2	90.4	0.73
	S.E.	± 2.84	± 4.78	± 0.07
F - 24 :	Av.	40.4	88.8	0.78
	S.E.	± 2.16	± 4.82	± 0.08
F - 25 :	Av.	36.2	71.2	0.74
	S.E.	± 2.12	± 4.36	± 0.07
F - 26 :	Av.	39.6	74.2	0.72
	S.E.	± 2.18	± 3.98	± 0.08
F - 27 :	Av.	41.6	86.2	0.74
	S.E.	± 2.56	± 3.74	± 0.07
F - 28 :	Av.	32.8	59.8	0.76
	S.E.	± 2.18	± 2.88	± 0.07
F - 29 :	Av.	26.4	63.0	0.70
	S.E.	± 2.76	± 4.56	± 0.08
F - 30 :	Av.	28.6	68.6	0.74
	S.E.	± 3.12	± 3.84	± 0.08
F - 31 :	Av.	34.8	82.4	0.76
	S.E.	± 2.16	± 3.18	± 0.04
F - 32 :	Av.	37.6	76.8	0.72
	S.E.	± 2.54	± 3.84	± 0.06

(Continue)

T - 33 :	Av.	38.0	87.8	0.72
	S.E.	± 1.98	± 4.56	± 0.07
T - 34 :	Av.	35.4	83.6	0.74
	S.E.	± 2.44	± 3.22	± 0.08
T - 35 :	Av.	38.6	87.4	0.70
	S.E.	± 2.58	± 4.36	± 0.06
T - 36 :	Av.	39.2	85.0	0.74
	S.E.	2.24	3.98	0.07

* 5 Replicates of 5 plants each

LEGENDS : Treatments = Please refer to Table - 6.1

Av. = Average,

S.E. = Standard error

said Tables exhibit the effects of *ut supra* treatments on the average growth increments *viz*., Photosynthetic area (cm^2), Shoot length (cm), Root length (cm), Plant length (cm) and the Shoot/root length ratio of 'Kardhai' seedlings. And lastly the section (c) of the Tables display the average biomass expansion and the percentage moisture contents in Leaves, Shoots, Roots, Total plant and the Shoot/root dry weight ratio of *A.pendula* seedlings.

6.4.(a) R O O T S

It is the part of a plant that grows down into the earth and conveys nourishment to the plant *en route* anchoring them in the soil. The observations of the growth of roots in *A.pendula* seedlings under various experimental treatments were quite interesting. Treatment - wise the maximum and the minimum average length of roots were as follows : In fertiliser treatments (Table - 6.2.b) it was 64.38 cm in the roots of the seedlings getting a dose of Phosphorus - 20 kg/ha and 46.32 cm with a dose of Nitrogen - 12 kg + Potassium - 20 kg/ha respectively. That was 20.06 % and 14.29 % bounce and drop respectively over the control (54.04 cm). The maximum and the minimum average dry matter production profit in the said treatment (Table - 6.2.c) were 3.6754 g and 2.5752 g in the roots of the seedlings

PLATE - 20. THE EFFECTS OF SPRAYING 500 ppm/ IBA ON ANOGEISSUS PENDULA SEEDLINGS. THE TREATED SEEDLINGS EXHIBITED THE MAXIMUM ROOT, SHOOT AND TOTAL PLANT LENGTHS AND ALSO THE MAXIMUM DRY MATTER PRODUCTIONS. THE SAME WAS COMPARED WITH A NORMAL PERFORMANCE OF THE SEEDLING UNDER CONTROL (C).

PLATE - 21. THE GROWTH BEHAVIOUR OF ANOGEISSUS PENDULA SEEDLINGS AS INFLUENCED BY SPRAYING 10 ppm/ME AND THE ONE UNDER CONTROL (C).


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acknowledgeing the same respective doses of fertilizer. That was 22.33 % and 14.29 % rise and fall respectively in regard with the biomass yielded by the roots of the seedlings under control (3.0044 g). The average moisture percentage were maximum 61.62 % in the roots of the seedlings bestowed with a dose of Nitrogen - 40 kg + Phosphorus - 40 kg + Potassium - 20 kg/ha. On the other side a minimum of 50.74 % moisture contents were recorded in the seedling - roots having a dose of Potassium - 20 kg/ha. These were 13.15 % and 6.83 % increase and decrease respectively over the control.

The growth and the biomass behaviour of the roots under hormonal treatments were : average maximum length of 59.58 cm (9.20 % profit over control) in the seedlings treated with 500 ppm/IBA and the average minimum length of 46.14 cm (15.43 % loss over control) in the seedlings treated with 500 ppm/KN (Table - 6.3.b). The average maximum (3.3720 g) and the minimum (2.6412 g) oven dry weights were witnessed in the roots of the seedlings applied with the similar respective hormonal concentrations (Table - 6.3.c). That was 11.72 % earning and 12.49 % spending respectively over the control (3.0182 g). The average moisture percentage in the roots

TABLE - 6.2.(b) EFFECT OF DIFFERENT COMBINATIONS OF INORGANIC FERTILIZERS (N P & K) ON THE AVERAGE GROWTH INCREMENT OF ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		PHOTOSYNTHETIC AREA (cm^2)	SHOOT LENGTH (cm)	ROOT LENGTH (cm)	TOTAL SEEDLING LENGTH (cm)	SHOOT/ROOT LENGTH RATIO
F - 1 :	AV.	134.6	25.46	54.04	79.50	0.4711
	S.E.	± 5.48	± 2.02	± 3.20	± 4.66	± 0.0214
F - 2 :	AV.	98.4	23.48	49.24	72.72	0.4768
	S.E.	± 3.66	± 1.38	± 3.16	± 4.18	± 0.0198
F - 3 :	AV.	95.6	22.88	50.18	73.06	0.4560
	S.E.	± 5.12	± 1.96	± 2.74	± 3.98	± 0.0166
F - 4 :	AV.	93.8	22.16	64.88	87.04	0.3416
	S.E.	± 3.84	± 1.78	± 2.14	± 5.72	± 0.0228
F - 5 :	AV.	112.4	24.76	63.28	87.04	0.3913
	S.E.	± 4.62	± 2.12	± 3.96	± 2.84	± 0.0236
F - 6 :	AV.	115.2	25.04	62.84	87.88	0.3985
	S.E.	± 5.14	± 1.16	± 2.84	± 5.66	± 0.0248
F - 7 :	AV.	91.4	21.56	64.96	86.52	0.3319
	S.E.	± 3.76	± 1.24	± 3.16	± 4.58	± 0.0416
F - 8 :	AV.	103.6	23.92	64.16	88.08	0.3728
	S.E.	± 4.84	± 2.16	± 3.84	± 5.12	± 0.0354
F - 9 :	AV.	108.8	24.32	63.78	88.10	0.3813
	S.E.	± 5.92	± 1.90	± 2.84	± 6.22	± 0.0282
F - 10:	AV.	159.6	34.84	52.28	87.12	0.6664
	S.E.	± 5.98	± 2.82	± 2.66	± 3.44	± 0.0362
F - 11:	AV.	156.8	33.58	48.06	81.64	0.6987
	S.E.	± 6.74	± 2.56	± 3.42	± 1.98	± 0.0428
F - 12:	AV.	154.8	32.22	48.92	81.14	0.6586
	S.E.	± 5.46	± 2.24	± 1.98	± 3.82	± 0.0492

(Continue)

(Continued)

F - 13	Av.	152.8	30.08	59.60	89.68	0.5047
	S.E.	± 6.66	± 2.16	± 3.84	± 5.84	± 0.0416
F - 14	Av.	137.2	26.86	61.32	88.18	0.4380
	S.E.	± 3.42	± 2.48	± 4.96	± 4.86	± 0.0512
F - 15	Av.	134.8	25.82	61.76	87.58	0.4181
	S.E.	± 5.16	± 2.92	± 3.88	± 5.68	± 0.0228
F - 16	Av.	149.8	29.12	60.02	89.14	0.4812
	S.E.	± 6.98	± 2.74	± 5.72	± 4.24	± 0.0334
F— 17	Av.	135.2	26.10	62.26	88.36	0.4192
	S.E.	± 5.48	± 3.16	± 3.44	± 4.76	± 0.0284
F - 18	Av.	136.6	26.32	62.66	88.98	0.4200
	S.E.	± 5.54	± 3.68	± 5.64	± 6.32	± 0.0292
F - 19	Av.	160.4	35.02	51.98	87.00	0.6737
	S.E.	± 9.78	± 2.24	± 2.84	± 5.16	± 0.0466
F - 20	Av.	157.8	34.00	47.54	81.54	0.7152
	S.E.	± 7.96	± 2.36	± 3.64	± 5.88	± 0.0516
F - 21	Av.	156.2	33.14	48.54	81.68	0.6827
	S.E.	± 9.22	± 3.12	± 3.82	± 6.14	± 0.0428
F - 22	Av.	153.6	31.48	57.26	88.74	0.5498
	S.E.	± 8.64	± 1.98	± 2.56	± 5.04	± 0.0336
F - 23	Av.	148.6	29.26	60.68	89.94	0.4822
	S.E.	± 7.48	± 2.66	± 3.82	± 3.46	± 0.0464
F - 24	Av.	138.2	27.58	60.98	88.56	0.4523
	S.E.	± 7.22	± 1.18	± 2.74	± 3.92	± 0.0510
F - 25	Av.	151.6	30.68	59.18	89.86	0.5154
	S.E.	± 8.56	± 1.98	± 2.84	± 4.66	± 0.0466

(Continue)

F - 26 :	Av.	140.4	27.92	60.24	88.16	0.4635
	S.E.	± 9.48	± 2.24	± 3.96	± 5.80	± 0.0384
F - 27 :	Av.	137.4	27.24	61.64	88.88	0.4419
	S.E.	± 7.66	± 1.64	± 5.74	± 4.12	± 0.0512
F - 28 :	Av.	161.2	35.18	50.80	85.98	0.6925
	S.E.	±11.28	± 2.28	± 3.88	± 3.36	± 0.0464
F - 29 :	Av.	158.2	34.52	46.32	80.84	0.7453
	S.E.	± 9.92	± 3.36	± 2.76	± 4.44	* 0.0528
F - 30 :	Av.	165.6	32.60	50.82	93.42	0.6415
	S.E.	±11.44	± 2.72	± 5.32	± 6.98	± 0.0472
F - 31 :	Av.	154.2	31.86	55.68	87.54	0.5722
	S.E.	±10.84	± 2.48	± 2.78	± 3.48	± 0.0612
F - 32 :	Av.	149.4	29.72	59.82	89.54	0.4968
	S.E.	± 8.44	± 2.16	± 3.88	± 3.92	± 0.0422
F - 33 :	Av.	146.6	28.32	61.08	89.40	0.4637
	S.E.	± 6.80	± 3.44	± 4.92	± 2.88	± 0.0478
F - 34 :	Av.	150.4	30.64	58.52	89.16	0.5236
	S.E.	±10.22	± 3.12	± 4.02	± 2.54	± 0.0516
F - 35 :	Av.	147.2	28.84	61.48	90.32	0.4691
	S.E.	± 9.32	± 2.32	± 2.64	± 7.90	± 0.0444
F - 36 :	Av.	147.8	28.96	61.96	90.92	0.4674
	S.E.	± 8.34	± 2.94	± 3.36	± 6.32	± 0.0528

* 5 Replicates of 5 Plants each

LEGENDS : Treatments = Please refer to Table 6.1

Av. = Average, S.E. = Standard error

were maximum 63.36 % in negotiation with 10 ppm/GA (3.09 % gain over control) and minimum 52.9[illegible] % in discourse with 10 ppm/IAA (13.86 % loss over control). The percentage moisture contents in the roots under control was 61.46 %.

While considering the effects of the seed weight and seed size on the performance of roots produced by A.pendula seedlings, it was perceived that the average maximum length (37.24 cm) and the maximum biomass (2.7166 g) were achieved through the heavy weighted - medium sized seeds, whereas, the average minimum length (7.82 cm) and the minimum dry weight (0.5492 g) were attained with the use of light weighted - large sized seeds (Table - 6.4.b and 6.4.c). The average percentage of the moisture contents present were maximum 59.56 % while using light weighted - medium sized seeds and the minimum 53.24 % while availing medium weighted - small sized seeds.

The tale about the affects of various compositions of potting media on the growth (Table - 6.5.b) and the biomass production (Table - 6.5.c) of roots was ut infra : Average maximum root length 60.44 cm in the seedlings grown exclusively in sand and the minimum of

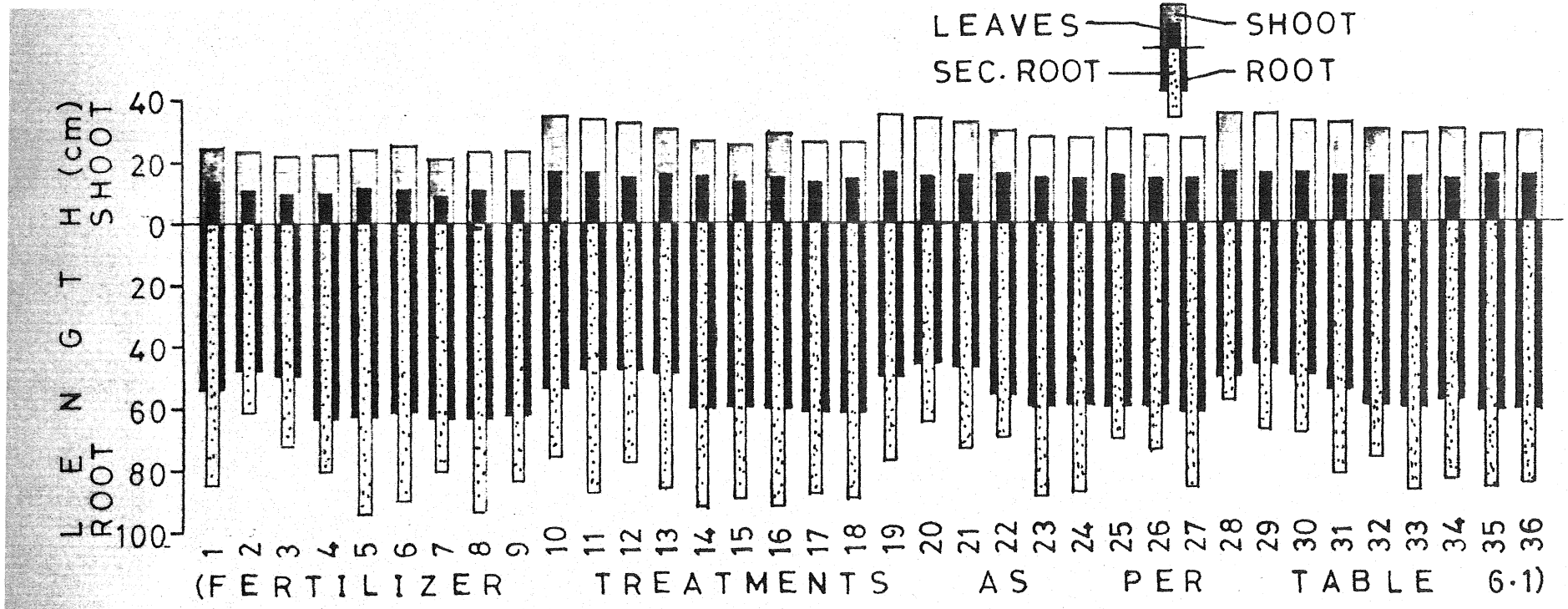


FIG. 6·1 GROWTH INCREMENT IN A. PENDULA SEEDLINGS AS INFLUENCED BY THE VARIOUS COMBINATIONS OF N, P & K FERTILIZER TREATMENTS.

TABLE - 6.2.(c) EFFECT OF VARIOUS COMBINATIONS OF INORGANIC FERTILIZERS (N P & K) ON THE AVERAGE DRY MATTER PRODUCTION AND PERCENTAGE MOISTURE CONTENTS IN ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		LEAVES		SHOOT**		ROOT		TOTAL SEEDLING		SHOOT/ROOT DRY WT. RATIO
		A	B	A	B	A	B	A	B	
F - 1	Av.	0.7656	75.38	1.3298	64.44	3.0044	54.46	4.3342	57.96	0.4426
	S.E.	± 0.0412	± 4.32	± 0.0844	± 2.68	± 0.2464	± 2.56	± 0.3646	± 3.18	± 0.0102
F - 2	Av.	0.6056	78.64	0.9642	62.58	2.7256	50.74	3.6898	54.12	0.3538
	S.E.	± 0.0214	± 3.96	± 0.0726	± 3.14	± 0.1592	± 2.92	± 0.2424	± 2.14	± 0.0196
F - 3	Av.	0.5914	80.26	0.9412	65.88	2.7668	50.88	3.7080	56.34	0.3412
	S.E.	± 0.0628	± 4.84	± 0.0714	± 4.28	± 0.0944	± 3.36	± 0.2418	± 3.30	± 0.0112
F - 4	Av.	0.5996	79.44	0.9124	60.72	3.6754	52.86	4.5878	55.56	0.2482
	S.E.	± 0.1066	± 3.84	± 0.0428	± 4.44	± 0.1928	± 4.54	± 0.3118	± 4.14	± 0.0188
F - 5	Av.	0.6584	78.32	1.1076	64.34	3.5418	58.32	4.6494	60.04	0.3127
	S.E.	± 0.0324	± 4.56	± 0.0762	± 2.92	± 0.2616	± 3.42	± 0.2204	± 3.86	± 0.0132
F - 6	Av.	0.6788	78.66	1.1384	61.28	3.4284	51.94	4.5668	54.68	0.3320
	S.E.	± 0.0294	± 4.16	± 0.0846	± 2.84	± 0.1918	± 3.84	± 0.2186	± 2.98	± 0.0164
F - 7	Av.	0.5498	78.82	0.8944	62.98	3.6158	55.46	4.5102	59.52	0.2474
	S.E.	± 0.0918	± 4.84	± 0.0466	± 3.66	± 0.2436	± 3.12	± 0.2162	± 3.76	± 0.0166
F - 8	Av.	0.6138	74.34	1.0016	60.06	3.5596	53.62	4.5612	57.90	0.2814
	S.E.	± 0.0274	± 3.96	± 0.1246	± 3.54	± 0.2664	± 4.44	± 0.3384	± 2.74	± 0.0202
F - 9	Av.	0.6268	78.14	1.0354	66.28	3.5532	59.68	4.5886	61.52	0.2914
	S.E.	± 0.0452	± 5.12	± 0.1188	± 2.98	± 0.2728	± 3.92	± 0.3158	± 4.22	± 0.0108
F - 10	Av.	0.9498	80.22	1.5528	65.82	2.9096	52.70	4.4624	57.84	0.5337
	S.E.	± 0.0926	± 4.18	± 0.1442	± 4.64	± 0.1858	± 4.16	± 0.2286	± 3.80	± 0.0102
F - 11	Av.	0.9322	72.86	1.5336	63.20	2.6674	58.04	4.2010	60.18	0.5749
	S.E.	± 0.0598	± 4.74	± 0.1164	± 4.16	± 0.2778	± 3.28	± 0.2118	± 4.36	± 0.0164

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F - 12	Av.	0.9416	76.94	1.5262	56.76	2.7198	53.42	4.2460	56.24	0.5611
	S.E.	± 0.0764	± 5.38	± 0.0988	± 3.98	± 0.0816	± 2.68	± 0.1824	± 3.78	± 0.0288
F - 13	Av.	0.9062	76.56	1.5002	61.24	3.3254	57.36	4.8256	59.62	0.4511
	S.E.	± 0.0622	± 3.16	± 0.1264	± 3.72	± 0.2172	± 3.92	± 0.3184	± 2.94	± 0.0212
F - 14	Av.	0.8098	74.14	1.3414	67.62	3.4078	52.90	4.7892	55.74	0.3956
	S.E.	± 0.0756	± 4.44	± 0.1286	± 4.12	± 0.2618	± 4.84	± 0.2726	± 3.66	± 0.0184
F - 15	Av.	0.7864	80.68	1.3168	60.94	3.4538	59.42	4.7706	60.04	0.3813
	S.E.	± 0.0822	± 2.86	± 0.1604	± 3.88	± 0.2764	± 4.62	± 0.1998	± 4.52	± 0.0124
F - 16	Av.	0.8758	75.04	1.4686	59.68	3.3598	59.74	4.8284	59.60	0.4371
	S.E.	± 0.0456	± 3.16	± 0.1198	± 5.18	± 0.1842	± 3.42	± 0.2812	± 2.58	± 0.0108
F - 17	Av.	0.7908	78.28	1.3288	57.80	3.4652	61.62	4.7940	59.42	0.3835
	S.E.	± 0.0854	± 4.62	± 0.0644	± 2.98	± 0.2298	± 2.98	± 0.1296	± 4.60	± 0.0164
F - 18	Av.	0.8092	80.42	1.3396	63.16	3.4716	57.86	4.8112	59.28	0.3859
	S.E.	± 0.0734	± 3.98	± 0.2486	± 3.84	± 0.1926	± 2.72	± 0.2384	± 3.96	± 0.0102
F - 19	Av.	0.9616	80.22	1.5748	69.64	2.9528	57.28	4.5276	62.84	0.5333
	S.E.	± 0.0722	± 4.12	± 0.1252	± 3.42	± 0.3140	± 3.38	± 0.5612	± 4.32	± 0.0202
F - 20	Av.	0.9482	78.56	1.5434	70.26	2.6014	59.80	4.1448	62.16	0.5933
	S.E.	± 0.0842	± 3.22	± 0.1628	± 2.84	± 0.0786	± 3.18	± 0.2204	± 3.86	± 0.0132
F - 21	Av.	0.9412	72.24	1.5394	63.60	2.6968	55.68	4.2362	59.32	0.5708
	S.E.	± 0.0636	± 3.14	± 0.0918	± 3.64	± 0.2864	± 4.14	± 0.2986	± 3.46	± 0.0298
F - 22	Av.	0.9118	76.82	1.5092	61.74	3.1710	58.32	4.6802	59.28	0.4759
	S.E.	± 0.0714	± 2.98	± 0.1726	± 3.68	± 0.2546	± 3.54	± 0.3708	± 3.28	± 0.0264
F - 23	Av.	0.8856	80.42	1.4526	65.38	3.3548	61.16	4.8074	62.44	0.4330
	S.E.	± 0.0372	± 4.16	± 0.0866	± 3.32	± 0.1732	± 3.64	± 0.1024	± 5.68	± 0.0278
F - 24	Av.	0.8266	79.36	1.3578	60.52	3.4056	57.64	4.7634	59.08	0.3987
	S.E.	± 0.0258	± 3.82	± 0.0654	± 4.22	± 0.2358	± 5.36	± 0.3918	± 4.72	± 0.0240
F - 25	Av.	0.9136	73.58	1.4924	64.32	3.2876	57.88	4.7800	61.92	0.4539
	S.E.	± 0.0244	± 3.76	± 0.2694	± 3.12	± 0.2464	± 3.24	± 0.3084	± 4.14	± 0.0324

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F - 26	Av.	0.8358	80.66	1.3822	68.12	3.3544	59.36	4.7366	63.26	0.4121
	S.E.	± 0.0416	± 3.12	± 0.1914	± 4.60	± 0.1462	± 4.16	± 0.2820	± 4.06	± 0.0198
F - 27	Av.	0.8136	78.82	1.3498	57.98	3.4236	58.32	4.7734	58.04	0.3943
	S.E.	± 0.0484	± 4.64	± 0.0982	± 2.44	± 0.2668	± 3.28	± 0.2338	± 3.78	± 0.0164
F - 28	Av.	0.9666	71.96	1.5986	63.92	2.8128	53.06	4.4114	57.78	0.5683
	S.E.	± 0.0622	± 3.38	± 0.1624	± 3.86	± 0.2784	± 4.32	± 0.3522	± 4.64	± 0.0108
F - 29	Av.	0.9416	80.02	1.5666	65.16	2.5752	54.78	4.1418	57.98	0.6083
	S.E.	± 0.0298	± 3.26	± 0.2016	± 2.48	± 0.1818	± 2.98	± 0.2724	± 3.94	± 0.0328
F - 30	Av.	0.9128	78.18	1.6384	63.22	2.8228	57.26	4.4612	59.08	0.5804
	S.E.	± 0.0614	± 4.58	± 0.1756	± 3.96	± 0.1652	± 2.72	± 0.1544	± 4.66	± 0.0268
F - 31	Av.	0.9156	76.58	1.5192	61.40	3.0978	57.26	4.6170	58.74	0.4904
	S.E.	± 0.0254	± 2.96	± 0.3618	± 2.98	± 0.2164	± 3.84	± 0.1074	± 2.76	± 0.0296
F - 32	Av.	0.8842	80.46	1.4662	67.24	3.3292	56.96	4.7954	59.86	0.4404
	S.E.	± 0.0296	± 3.54	± 0.2184	± 2.78	± 0.1928	± 4.62	± 0.1968	± 4.62	± 0.0202
F - 33	Av.	0.8656	75.24	1.4380	66.44	3.4078	56.84	4.8458	60.72	0.4220
	S.E.	± 0.0314	± 3.72	± 0.1462	± 3.46	± 0.2668	± 3.92	± 0.2896	± 3.54	± 0.0212
F - 34	Av.	0.8884	77.12	1.4756	65.84	3.2476	59.42	4.7232	62.18	0.4544
	S.E.	± 0.0734	± 4.16	± 0.0922	± 4.44	± 0.1892	± 4.76	± 0.3712	± 4.20	± 0.0134
F - 35	Av.	0.8594	79.92	1.4374	65.16	3.4238	55.08	4.8612	61.46	0.4198
	S.E.	± 0.0482	± 4.38	± 0.0726	± 3.76	± 0.0896	± 2.98	± 0.2828	± 3.88	± 0.0298
F - 36	Av.	0.8492	80.64	1.4382	66.36	3.4498	57.68	4.8880	62.28	0.4169
	S.E.	± 0.0414	± 2.98	± 0.0674	± 3.84	± 0.1814	± 4.64	± 0.3532	± 4.86	± 0.0112

* 5 Replicates of 5 plants each

** Including values of leaves

LEGENDS : Treatments = See Table 6.1

A = Average dry weight (g), B = Percent moisture

11.46 cm length in the seedlings grown in pure peat. The maximum average dry weight (3.3422 g) was obtained in the roots spreading in a soil mixture containing sand and black soil (3 : 1 ratio by volume), whereas, the minimum average biomass (0.6583 g) was noticed in the roots developing in sole peat. Maximum 61.56 % and minimum 54.96 % moisture was present in the roots that enjoyed pure black soil and the pure sand respectively.

The effects of spacing treatments (Table - 6.6.b and 6.6.c) on the behaviour of roots were as follows : Average maximum length (40.16 cm), dry matter (2.6282 g) and the moisture contents (59.22 %) were documented in the roots of the seedlings grown with a plant to plant spacing of 20 cm, 25 cm and 14.2 cm distance respectively. However, the minimum length (12.06 cm), biomass (1.2624 g) and the moisture (51.16 %) were invariably observed in the roots of the seedlings grown with a plant to plant spacing of 5 cm distance.

The conduct of the secondary roots also varied with different treatments. The maximum and the minimum average number of secondary roots were 45.6 and 26.4 in the seedlings given a dose of Phosphorus - 40 kg/ha and Nitrogen -120 kg + Potassium - 20 kg/ha respectively

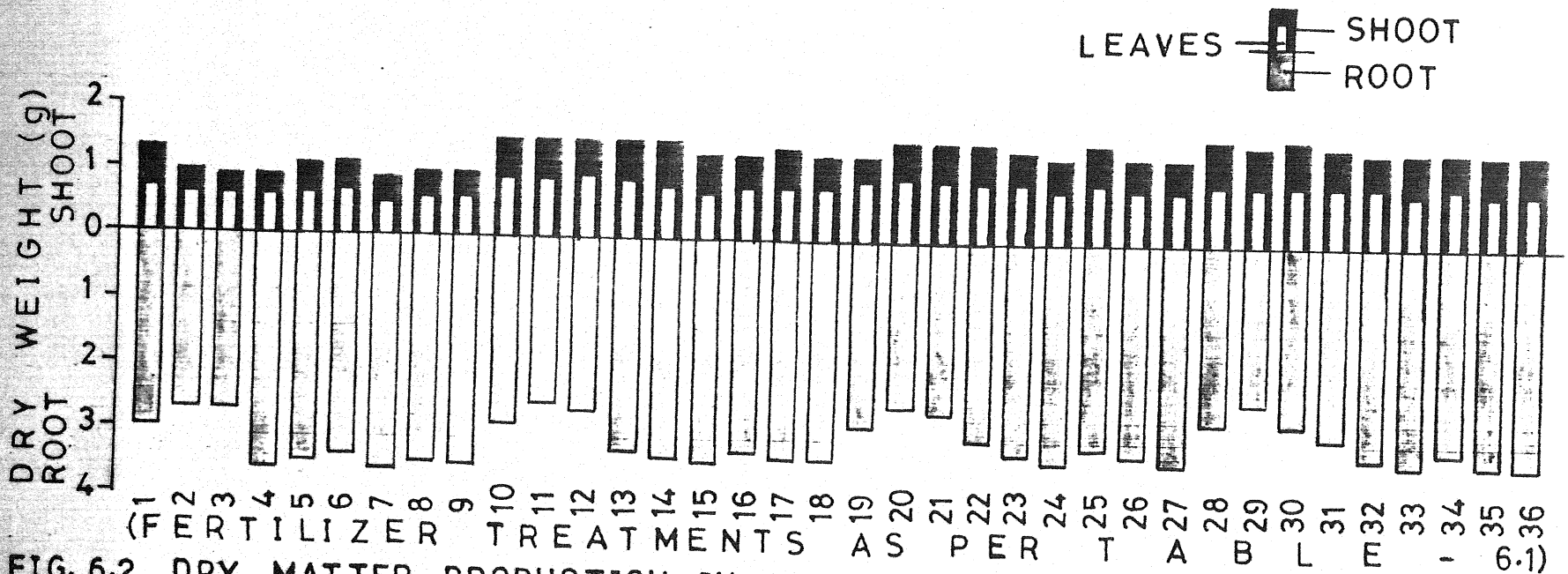
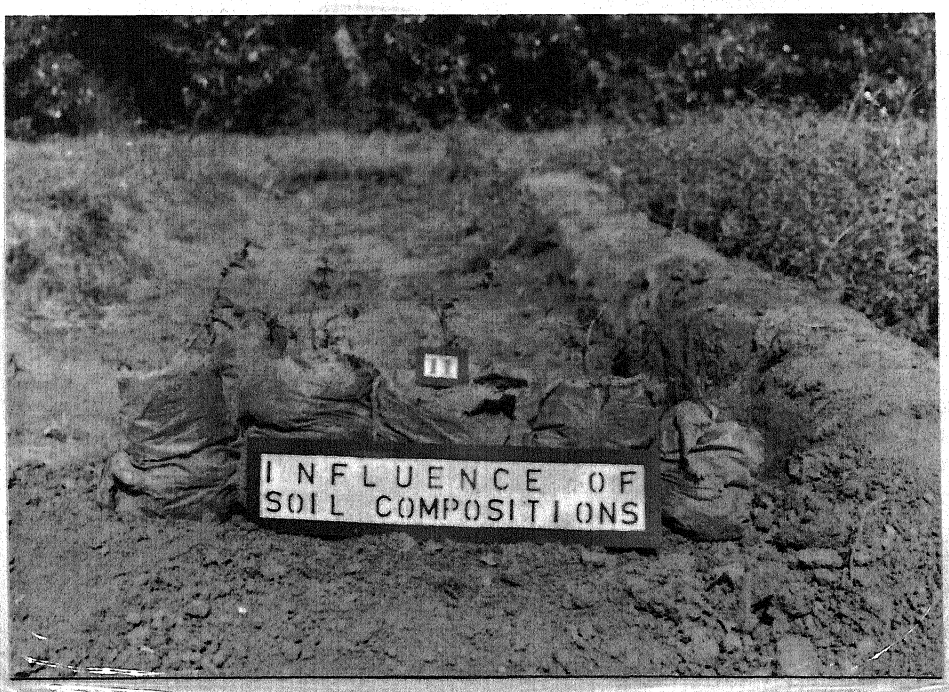


FIG. 6.2 DRY MATTER PRODUCTION IN A.PENDULA SEEDLINGS AS AFFECTED BY FERTILIZING THEM THROUGH VARIOUS COMBINATIONS OF N., P. & K. FERTILIZERS.

PLATE - 22. THE DISPLAY OF GROWTH ACHIEVEMENTS BY ANOGEISSUS PENDULA SEEDLINGS AS ALTERED BY GROWING THEM IN A SOIL MIXTURE OF SAND : BLACK : AND RED SOILS IN 2 : 1 : 1 RATIO BY VOLUME.

PLATE - 23. THE POOREST PERFORMANCES IN ALL THE DEPARTMENTS OF GROWTH BY ANOGEISSUS PENDULA SEEDLINGS GROWN IN A SOIL COMPOSITION CONTAING PURE PEAT.


[O]
INFLUENCE OF
SOIL COMPOSITIONS


[1]
INFLUENCE OF
SOIL COMPOSITIONS

(Table - 6.2.a) that were 33.33 % and 22.80 % profit and loss respectively over the control (34.2). In growth hormones it were 48.4 and 33.4 in 10 ppm/GA and 500 ppm/IPA respectively (Table - 6.3.a), that were 32.24 % and 8.74 % plus and minus respectively than that of the control (36.6). As regards the affects of seed weight and seed size, the maximum average of 32.8 secondary roots were obtained in the seedlings produced by the heavy weighted - medium sized seeds, whereas, the minimum average of 10.4 secondary roots were procured through the light weighted - large sized seeds of A.pendula (Table - 6.4.a). The affect of various soil compositions reveal that the maximum average of 50.2 secondary roots were induced in the seedlings grown in pure sand, whereas, the minimum of 19.2 secondary roots were achieved in the seedlings grown exclusively in Peat (Table - 6.5.a). With respect to the affects due to spacing trials, the maximum average of 30 secondary roots were sighted in the seedlings grown with a plant to plant distance of 14.2 cm, whereas, the minimum average of 11.2 secondary roots were perceived in the seedlings grown with a plant to plant distance of 5 cm (Table - 6.6.a).

TABLE - 6.3.(a) EFFECT OF DIFFERENT CONCENTRATIONS OF VARIOUS GROWTH HORMONES ON THE NUMBER AND TOTAL LENGTH (cm) OF SECONDARY ROOTS, AND COLLAR GIRTH (cm) OF *ANOGEISSUS PENDULA* SEEDLINGS*.

TREATMENTS		NUMBER OF SECONDARY ROOTS	LENGTH OF SECONDARY ROOTS	COLLAR CIRCUMFERENCE
H - 1 :	Av.	46.0	88.4	0.76
	S.E.	± 3.16	± 3.98	± 0.08
H - 2 :	Av.	40.0	90.6	0.74
	S.E.	± 2.72	± 3.78	± 0.08
H - 3 :	Av.	39.6	79.2	0.74
	S.E.	± 2.66	± 2.16	± 0.06
H - 4 :	Av.	38.2	90.0	0.78
	S.E.	± 1.98	± 4.22	± 0.07
H - 5 :	Av.	41.0	92.8	0.78
	S.E.	± 2.74	± 2.34	± 0.06
H - 6 :	Av.	46.8	88.6	0.80
	S.E.	± 2.62	± 3.16	± 0.09
H - 7 :	Av.	40.6	86.2	0.74
	S.E.	± 1.68	± 3.76	± 0.07
H - 8 :	Av.	41.4	85.6	0.74
	S.E.	± 1.44	± 2.26	± 0.08
H - 9 :	Av.	33.4	86.0	0.72
	S.E.	± 2.04	± 3.48	± 0.08
H - 10 :	Av.	48.4	89.4	0.76
	S.E.	± 2.26	± 2.92	± 0.06
H - 11 :	Av.	46.8	90.2	0.76
	S.E.	± 1.98	± 3.52	± 0.06
H - 12 :	Av.	40.4	90.6	0.72
	S.E.	± 2.12	± 3.48	± 0.07

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H - 13 :	Av.	41.8	88.8	0.82
	S.E.	± 1.92	± 2.76	± 0.06
H - 14 :	Av.	42.6	80.2	0.84
	S.E.	± 2.04	± 2.42	± 0.06
H - 15 :	Av.	38.8	74.2	0.84
	S.E.	± 1.76	± 3.12	± 0.09
H - 16 :	Av.	36.6	84.8	0.68
	S.E.	± 1.44	± 2.98	± 0.08
H - 17 :	Av.	36.6	82.6	0.70
	S.E.	± 1.76	± 1.84	± 0.06
H - 18 :	Av.	36.4	81.6	0.70
	S.E.	± 00.98	± 2.34	± 0.06
H - 19 :	Av.	38.6	86.0	0.68
	S.E.	± 1.96	± 2.12	± 0.08
H - 20 :	Av.	38.2	72.6	0.68
	S.E.	± 1.76	± 1.68	± 0.06
H - 21 :	Av.	39.0	68.8	0.66
	S.E.	± 1.92	± 2.12	± 0.06
H - 22 :	Av.	36.6	88.8	0.72
	S.E.	± 1.86	± 3.76	± 0.08

* 5 Replicates of 5 plants each

LEGENDS : Treatments = Please refer to Table - 6.1

Av. = Average,

S.E. = Standard error

Similarly, the maximum and the minimum average of the total length of secondary roots in the seedlings were *at infra* : In Fertilizers : 94.8 cm and 58.8 cm in Phosphorus + Potassium - each 20 kg/ha and Nitrogen - 120 kg/ha treatments respectively (Table - 6.2.a). That were 11.53 % and 30.82 % more and less respectively over the control (85.0 cm). In growth hormones : 92.8 cm and 68.8 cm in the seedlings sprayed with 100 ppm/IBA and 500 ppm/GOD respectively (Table - 6.3.a). That were 4.5 % and 22.52 % rise and fall respectively in reference to the control (88.8 cm). In seed weight and seed size : 76.2 cm and 12.6 cm in the seedlings germinated from the heavy weighted - medium sized seeds and the light weighted - large sized seeds respectively (Table - 6.4.a). In soil compositions : 94.8 cm and 24.2 cm in the seedlings grown exclusively in sand and in peat respectively (Table - 6.5.a). In Density : 87.4 cm and 32.4 cm in the seedlings induced with a plant to plant distance of 20 cm and 5 cm respectively (Table - 6.6.a).

6.4.(b) S H O O T S

It is the part of a plant which develops from the plumule and bear leaves. Regarding results of the

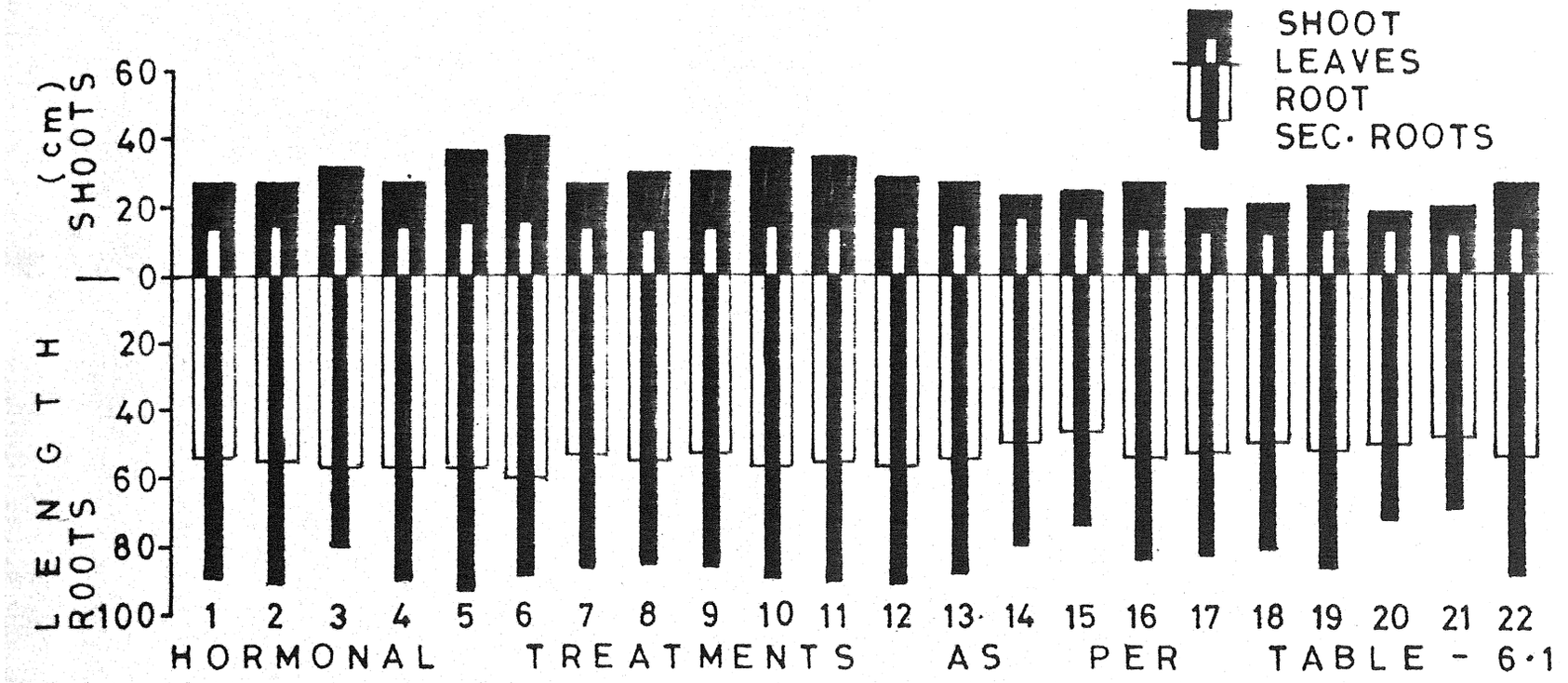


FIG. 6·3 HISTOGRAMS DEPICTING 12 MONTHS EFFECT OF DIFFERENT CONC. OF VARIOUS GROWTH HORMONES ON THE GROWTH INCREMENT OF A. PENDULA SEEDLINGS.

TABLE - 6.3.(b) EFFECT OF DIFFERENT CONCENTRATIONS OF VARIOUS GROWTH HORMONES ON THE AVERAGE GROWTH INCREMENT OF *ANOGEISSUS PENDULA* SEEDLINGS*.

TREATMENTS		PHOTOSYNTHETIC AREA (cm^2)	SHOOT LENGTH (cm)	ROOT LENGTH (cm)	TOTAL SEEDLING LENGTH (cm)	SHOOT/ROOT LENGTH RATIO
H - 1 :	Av.	137.6	26.58	53.84	80.42	0.4937
	S.E.	± 4.46	± 1.26	± 2.78	± 3.12	± 0.0112
H - 2 :	Av.	142,6	26.92	54.60	81.52	0.4930
	S.E.	± 3.92	± 2.12	± 2.46	± 2.98	± 0.0264
H - 3 :	Av.	145.8	31.66	57.24	88.90	0.5531
	S.E.	± 2.84	± 1.74	± 2.86	± 3.44	± 0.0276
H - 4 :	Av.	141.2	26.32	56.94	83.26	0.4622
	S.E.	± 4.36	± 1.84	± 2.82	± 3.16	± 0.0312
H - 5 :	Av.	158.6	37.12	57.62	94.74	0.6442
	S.E.	± 3.98	± 2.06	± 3.02	± 2.98	± 0.0202
H - 6 :	Av.	165.8	40.78	59.58	100.36	0.6845
	S.E.	± 4.72	± 2.76	± 2.76	± 4.64	± 0.0202
H - 7 :	Av.	139.4	26.42	53.80	80.82	0.4911
	S.E.	± 3.16	± 2.02	± 2.16	± 2.98	± 0.0112
H - 8 :	Av.	136.6	29.42	54.86	84.28	0.5363
	S.E.	± 2.40	± 1.66	± 3.82	± 2.76	± 0.0198
H - 9 :	Av.	138.4	29.84	53.48	83.32	0.5580
	S.E.	± 2.76	± 0.92	± 3.16	± 2.16	± 0.0202
H - 10:	Av.	142.2	36.82	56.82	93.64	0.6480
	S.E.	± 6.84	± 2.84	± 2.48	± 4.48	± 0.0284
H - 11:	Av.	133.4	34.78	55.64	90.42	0.6251
	S.E.	± 6.52	± 2.66	± 3.28	± 4.84	± 0.0136
H - 12:	Av.	136.2	28.34	57.06	85.40	0.4967
	S.E.	± 5.16	± 3.04	± 2.98	± 3.96	± 0.0124

(Continue)

(Continued)

H - 13 :	Av.	148.0	27.46	54.82	82.28	0.5009
	S.E.	± 2.66	± 1.66	±+2.34	± 3.16	± 0.0198
H - 14 :	Av.	164.8	23.42	50.06	73.48	0.4678
	S.E.	± 2.98	± 1.74	± 3.64	± 2.98	± 0.0112
H - 15 :	Av.	170.2	24.28	46.14	70.42	0.5262
	S.E.	± 4.14	± 1.98	± 2.94	± 3.48	± 0.0124
H - 16 :	Av.	136.4	26.42	54.78	81.20	0.4823
	S.E.	± 3.66	± 0.96	± 2.14	± 3.76	± 0.0132
H - 17 :	Av.	150.2	18.84	52.92	71.76	0.3560
	S.E.	± 2.74	± 1.06	± 2.86	± 3.84	± 0.0112
H - 18 :	Av.	121.4	20.86	50.26	71.12	0.4150
	S.E.	± 2.84	± 1.12	± 2.24	± 4.12	± 0.0102
H - 19 :	Av.	134.6	25.96	52.88	78.84	0.4909
	S.E.	± 2.66	± 1.06	± 2.08	± 3.64	± 0.0102
H - 20 :	Av.	131.8	17.82	50.24	68.06	0.3547
	S.E.	± 3.72	± 0.98	± 2.32	± 2.98	± 0.0184
H - 21 :	Av.	127.6	19.06	48.58	67.64	0.3923
	S.E.	± 4.16	± 1.14	± 3.18	± 3.48	± 0.0132
H - 22 :	Av.	138.6	26.26	54.56	80.82	0.4813
	S.E.	± 2.04	± 1.36	± 3.04	± 4.56	± 0.0148

* 5 Replicates of 5 plants each

LEGENDS : Treatments Please refer to Table 6.1

Av. = Average,

S.E. = Standard error

performance of A.pendula seedling - shoots under various treatment trials, the datum suggest that the maximum and the minimum average values of its length varied considerably. In inorganic Fertilizers the maximum shoot length of 35.13 cm was recorded in the seedlings provided with a dose of Nitrogen - 120 kg/ha and the minimum length of 21.56 cm with a dose of phosphorus 40 kg/ha (Table - 6.2.b). That were 38.13 % profit and 15.32 % loss respectively over the control (25.46 cm). In Hormonal treatments the maximum (40.78 cm) and the minimum (17.82 cm) shoot lengths were witnessed in the seedlings sprayed with 500 ppm/ IBA and 100 ppm/COU (Table - 6.3.b), with 55.29 % and 32.14 % benefit and retrenchment respectively over control (26.26 cm). Seed polymorphism revealed (Table - 6.4.b) that the heavy weighted - medium sized seeds yielded longest shoots of 20.86 cm average length, whereas, the light weighted - large sized seeds induced shortest shoots of 8.28 cm average length. Trials under soil compositions declared that a mixture of sand and black soil in 3 : 1 ratio by volume was the best in attaining the maximum average shoot length of 30.84 cm, while, on the contrary a composition of

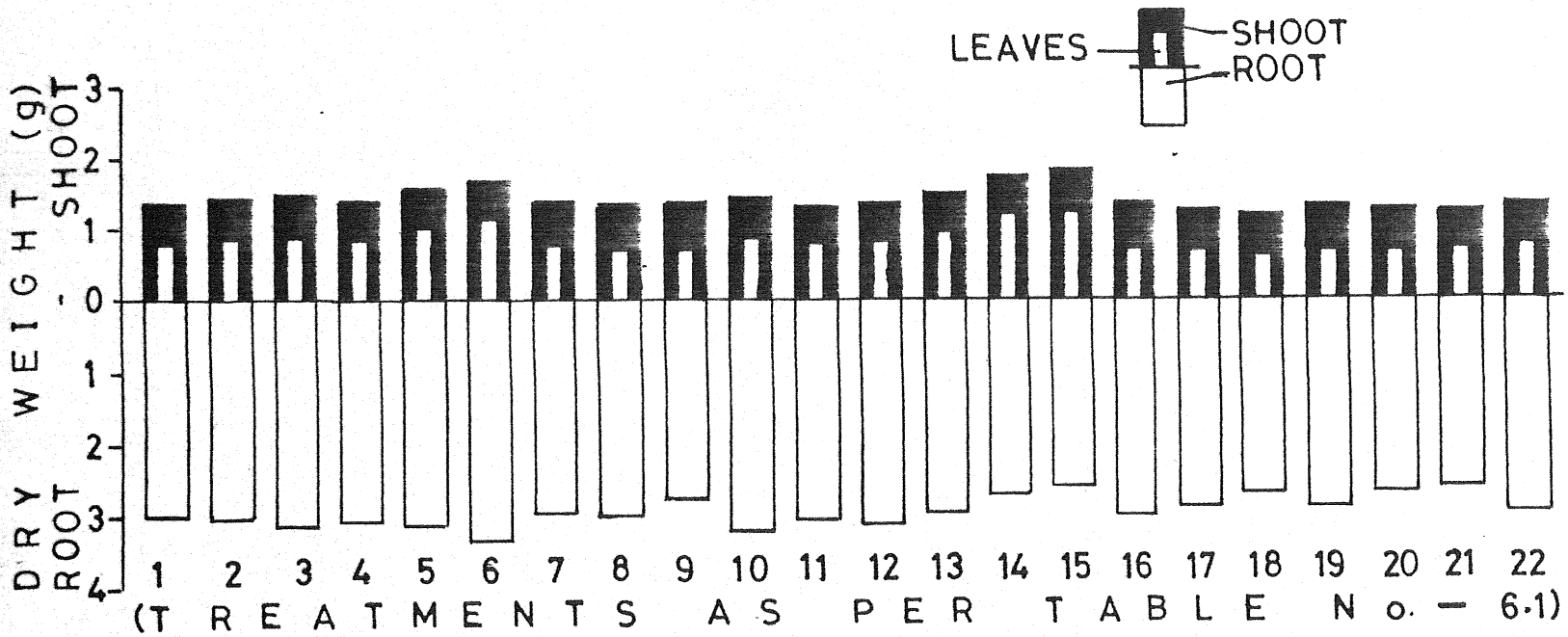


FIG. 6.4 DRY MATTER PRODUCTION IN A. PENDULA SEEDLINGS AS INFLUENCED BY DIFFERENT CONCENTRATIONS OF VARIOUS HORMONAL TREATMENTS.

TABLE - 6.3.(c) EFFECT OF DIFFERENT CONCENTRATIONS OF VARIOUS GROWTH HORMONES ON THE AVERAGE DRY MATTER PRODUCTION AND PERCENTAGE MOISTURE CONTENTS IN ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		LEAVES		SHOOT		ROOT		TOTAL SEEDLING		SHOOT/ROOT DRY Wt. RATIO
		A	B	A	B	A	B	A	B	
H - 1	Av.	0.8046	73.64	1.3642	58.26	3.0042	52.94	4.3684	56.35	0.4541
	S.E.	± 0.0634	± 2.18	± 0.0816	± 2.18	± 0.1292	± 2.68	± 0.2896	± 3.16	± 0.0278
H - 2	Av.	0.8698	79.92	1.4856	58.66	3.0134	53.66	4.4990	55.98	0.4930
	S.E.	± 0.0244	± 3.24	± 0.0892	± 2.26	± 0.2904	± 2.18	± 0.2184	± 2.74	± 0.0166
H - 3	Av.	0.9074	81.48	1.4966	67.12	3.1880	60.14	4.6846	62.21	0.4694
	S.E.	± 0.0212	± 3.66	± 0.0422	± 3.56	± 0.2186	± 3.74	± 0.2366	± 2.98	± 0.0098
H - 4	Av.	0.8224	82.82	1.4072	63.18	3.1012	62.46	4.5084	62.68	0.4538
	S.E.	± 0.0202	± 3.78	± 0.0516	± 3.44	± 0.2028	± 3.92	± 0.2082	± 3.44	± 0.0102
H - 5	Av.	1.0186	79.64	1.5978	65.24	3.1770	57.42	4.7748	59.82	0.5029
	S.E.	± 0.0264	± 3.92	± 0.0664	± 2.86	± 0.2764	± 2.86	± 0.2754	± 3.04	± 0.0112
H - 6	Av.	1.1346	81.02	1.6844	67.26	3.3720	63.02	5.0564	64.37	0.4995
	S.E.	± 0.0312	± 2.98	± 0.0814	± 3.18	± 0.2158	± 2.70	± 0.2918	± 2.76	± 0.0218
H - 7	Av.	0.7654	78.44	1.3704	64.92	3.0016	59.32	4.3720	60.97	0.4566
	S.E.	± 0.0198	± 3.66	± 0.0612	± 2.98	± 0.3166	± 2.56	± 0.2736	± 1.88	± 0.0102
H - 8	Av.	0.6986	72.28	1.3562	58.48	3.0404	58.02	4.3966	58.16	0.4461
	S.E.	± 0.0264	± 4.12	± 0.0424	± 3.46	± 0.3462	± 3.32	± 0.2852	± 2.70	± 0.0196
H - 9	Av.	0.6872	80.46	1.3724	62.44	2.8110	59.94	4.1834	60.74	0.4882
	S.E.	± 0.0212	± 3.78	± 0.0516	± 2.82	± 0.2926	± 3.16	± 0.1948	± 3.14	± 0.0284
H - 10	Av.	0.8398	80.34	1.4422	68.24	3.2360	63.36	4.6782	64.79	0.4457
	S.E.	± 0.0366	± 2.86	± 0.0788	± 3.94	± 0.2734	± 3.82	± 0.2234	± 3.04	± 0.0132
H - 11	Av.	0.7822	83.54	1.3026	62.52	3.0958	57.16	4.3984	58.65	0.4208
	S.E.	± 0.0724	± 4.16	± 0.0916	± 2.18	± 0.2164	± 3.72	± 0.3698	± 2.88	± 0.0312

(Continue)

(Continued) (11)

H - 12	Av.	0.7906	79.60	1.3564	65.16	3.1892	58.94	4.5456	60.67	0.4253
	S.E.	± 0.0316	± 3.34	± 0.0728	± 2.98	± 0.3948	± 2.64	± 0.3536	± 2.44	± 0.0282
H - 13	Av.	0.9490	79.18	1.5094	65.64	3.0118	56.38	4.5212	59.17	0.5012
	S.E.	± 0.0198	± 3.58	± 0.0344	± 3.74	± 0.4014	± 2.38	± 0.3118	± 2.92	± 0.0216
H - 14	Av.	1.2012	77.84	1.7418	56.20	2.7348	58.66	4.4766	58.25	0.6369
	S.E.	± 0.0224	± 2.98	± 0.0614	± 2.84	± 0.2752	± 3.44	± 0.4084	± 2.86	± 0.0198
H - 15	Av.	1.2146	82.28	1.8332	58.86	2.6412	58.94	4.4744	58.95	0.6941
	S.E.	± 0.0174	± 3.54	± 0.0254	± 4.16	± 0.2066	± 3.16	± 0.2896	± 3.44	± 0.0176
H - 16	Av.	0.7072	79.26	1.3708	63.06	3.0418	55.74	4.4126	57.83	0.4507
	S.E.	± 0.0168	± 3.72	± 0.0228	± 2.46	± 0.1984	± 1.98	± 0.3114	± 2.58	± 0.0216
H - 17	Av.	0.6998	76.24	1.2782	67.46	2.9122	60.08	4.1904	62.15	0.4389
	S.E.	± 0.0242	± 2.86	± 0.0316	± 3.18	± 0.2144	± 2.16	± 0.2368	± 2.48	± 0.0144
H - 18	Av.	0.6044	77.84	1.1906	69.92	2.7560	57.16	3.9466	60.49	0.4320
	S.E.	± 0.0212	± 2.74	± 0.0288	± 2.72	± 0.2286	± 2.64	± 0.3744	± 2.70	± 0.0172
H - 19	Av.	0.6826	76.16	1.3144	62.78	2.9432	60.46	4.2576	61.16	0.4466
	S.E.	± 0.0336	± 2.58	± 0.0316	± 1.98	± 0.1024	± 3.44	± 0.3162	± 3.06	± 0.0196
H - 20	Av.	0.6898	78.80	1.2843	61.14	2.7418	58.72	4.0266	59.47	0.4636
	S.E.	± 0.0272	± 3.14	± 0.0446	± 2.44	± 0.1984	± 2.96	± 0.2928	± 2.64	± 0.0212
H - 21	Av.	0.7304	76.26	1.2472	64.10	2.6674	59.24	3.9146	60.71	0.4676
	S.E.	± 0.0264	± 3.46	± 0.0414	± 2.76	± 0.1192	± 2.84	± 0.4008	± 2.28	± 0.0112
H - 22	Av.	0.7526	76.30	1.3644	64.22	3.0182	61.46	4.3826	61.87	0.4521
	S.E.	± 0.0314	± 2.98	± 0.0712	± 3.18	± 0.2106	± 2.72	± 0.2926	± 2.96	± 0.0196

* 5 Replicates of 5 plants each

** Including values of leaves

LEGENDS : Treatments = See Table 6.1

A = Average dry matter (g)

B = Moisture percentage

TABLE - 6.4.(a) EFFECT OF SEED WEIGHT AND SEED SIZE ON THE NUMBER AND TOTAL LENGTH (cm) OF SECONDARY ROOTS AND COLLAR GIRTH (cm) OF ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		NUMBER OF SEC. ROOTS	LENGTH OF SEC. ROOTS	COLLAR CIRCUMFERENCE
W - 1	Av.	12.00	20.40	0.56
	S.E.	± 1.02	± 1.64	± 0.04
W - 2	Av.	32.80	76.20	0.64
	S.E.	± 2.76	± 2.94	± 0.06
W - 3	Av.	20.60	58.80	0.60
	S.E.	± 1.98	± 3.16	± 0.05
W - 4	Av.	16.40	23.20	0.58
	S.E.	± 1.76	± 1.58	± 0.04
W - 5	Av.	17.20	24.80	0.58
	S.E.	± 1.98	± 1.66	± 0.03
W - 6	Av.	17.20	28.40	0.58
	S.E.	± 2.02	± 1.66	± 0.03
W - 7	Av.	10.40	12.60	0.52
	S.E.	± 0.76	± 1.12	± 0.04
W - 8	Av.	11.60	18.20	0.52
	S.E.	± 0.76	± 1.44	± 0.05
W - 9	Av.	11.20	17.40	0.54
	S.E.	± 0.76	± 1.98	± 0.04

* 5 Replicates of 5 plants each

LEGENDS : Treatments = Please refer to the Table - 6.1

Av. = Average, S.E. = Standard error

pure peat was the poorest as the seedlings growing on it produced the minimum average shoot length of 11.34 cm (Table - 6.5.b). Experiment laid for determining the best density exhibited that the maximum (1[illegible].56 cm) and the minimum (8.36 cm) average shoot lengthe were achieved in the seedlings grown with a plant to plant spacing of 2.5 cm and 5 cm distance respectively (Table - 6.6.b).

The maximum and the minimum dry matter productions in shoots of A.pendula seedlings were at infra : In Inorganic Fertilizers (Table - 6.2.c) : 1.6384 g under Nitrogen - 120 kg + Potassium - 40 kg/ha treatments and 0.8944 g under Phosphorus - 40 kg/ha treatments respectively. That were 23.21 % and 32.74 % advantage and bereavement respectively over the control (1.3298 g). In growth Hormones (Table - 6.3.c) : 1.8332 g in 500 ppm/ml (34.36 % increase) and 1.1906 g in 500 ppm/ml (12.74 % decrease) respectively as against 1.3644 g in control. In Seed weight and seed size classes (Table - 6.4.c) : 1.2106 g and 0.5228 g through heavy weighted - medium sized seeds and light weighted - large sized seeds respectively. In soil compositions (Table - 6.5.c) : 1.5824 g and 0.5168 g in a mixture

TABLE - 6.4.(b) EFFECT OF SEED - WEIGHT AND SEED - SIZE ON THE AVERAGE GROWTH INCREMENT OF ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		PHOTOSYNTHETIC AREA (cm^2)	SHOOT LENGTH (cm)	ROOT LENGTH (cm)	TOTAL SEEDLING LENGTH (cm)	SHOOT/ROOT LENGTH RATIO
W - 1 :	Av.	82.4	12.12	15.86	27.98	0.7642
	S.E.	± 2.58	± 0.98	± 0.76	± 1.12	± 0.0316
W - 2 :	Av.	116.8	20.86	37.24	58.10	0.5602
	S.E.	± 3.96	± 1.16	± 0.92	± 2.88	± 0.0184
W - 3 :	Av.	78.4	17.86	27.96	45.82	0.6388
	S.E.	± 2.92	± 1.24	± 1.88	± 2.76	± 0.0224
W - 4 :	Av.	67.8	14.96	19.10	34.06	0.7832
	S.E.	± 2.44	± 1.02	± 1.12	± 2.16	± 0.0298
W - 5 :	Av.	70.4	16.06	24.92	40.98	0.6444
	S.E.	± 3.62	± 1.02	± 1.56	± 2.16	± 0.0256
W - 6 :	Av.	70.6	16.22	21.62	37.84	0.7502
	S.E.	± 3.16	± 0.98	± 1.66	± 1.98	± 0.0316
W - 7 :	Av.	54.8	8.28	7.82	16.10	1.0588
	S.E.	± 2.24	± 0.66	± 0.44	± 1.06	± 0.0414
W - 8 :	Av.	56.8	10.80	11.00	21.80	0.9818
	S.E.	± 2.78	± 0.72	± 0.58	± 1.12	± 0.0396
W - 9 :	Av.	48.8	9.70	9.64	19.34	1.0062
	S.E.	± 2.98	± 0.98	± 0.62	± 1.32	± 0.0396

* 5 Replicates of 5 plants each

LEGENDS : Treatments = Please refer to Table 6.1

Av. = Average,

S.E. = Standard error

of Sand : Black soil (3 : 1 ratio by volume) and sole peat respectively. In spacing trials (Table - 6.6.c) : 1.2734 g and 0.9578 g with a plant to plant distance of 25 cm and 5 cm respectively.

As regards the maximum and the minimum percentage of the average moisture contents in shoots of A.pendula seedlings, the Tables suggest that treatment - wise the following maximum amounts of moisture contents were present :- 70.26 % in Nitrogen - 80 kg + Potassium - 40 kg/ha dose; 69.92 % in 500 ppm/Ml spraying ; 66.84 % through light weighted - large sized seeds; 68.94 % in a mixture of peat and black soil with 3 : 1 ratio by volume; and 66.94 % with a plant to plant spacing of 20 cm distance. On the other hand, the minimum amounts of moisture contents were recorded ut infra :- 56.76 % in Nitrogen + Potassium - each 40 kg/ha dose; 56.76 % in 100 ppm/Ml spraying; 59.38 % through light weighted - medium sized seeds; 58.52 % in a mixture of sand and black soil with 3 : 1 ratio by volume; and 58.84 % with a plant to plant spacing of 5 cm distance.

6.4.(c) L E A V E S

These are the part of plant's foliage

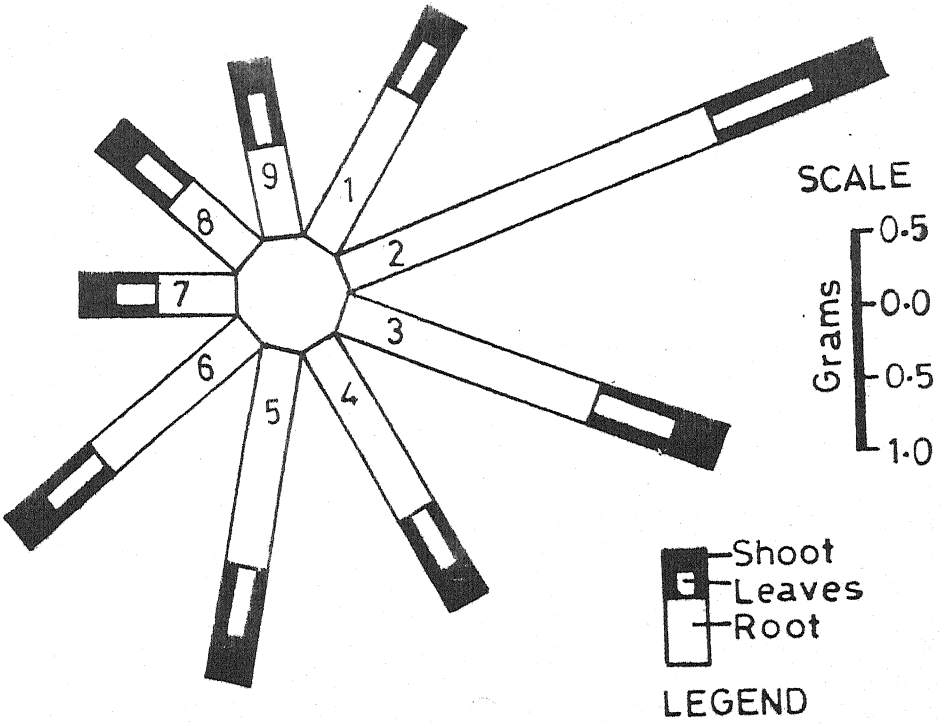


FIG. 6·5A-HISTOGRAM DEPICTING AVERAGE DRY MATTER PRODUCTIONS IN A. PENDULA SEEDLINGS AS AFFECTED BY SEED WEIGHT AND SIZE.

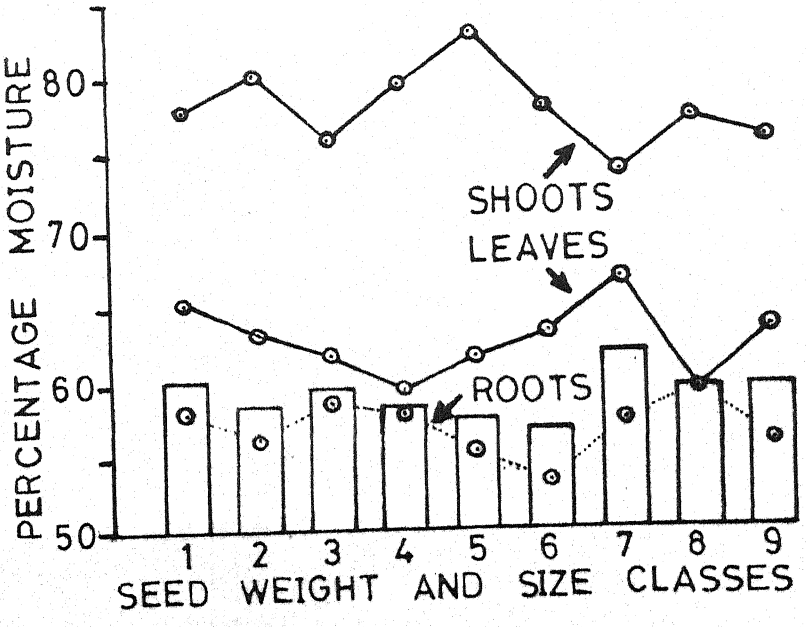


FIG. 6·5B-EFFECT OF SEED WEIGHT AND SIZE ON MOISTURE PERCENTAGE IN A. PENDULA SEEDLINGS. BARS REPRESENTS TOTAL MOISTURE CONTENTS IN THE SEEDLINGS.

TABLE - 6.4.(c) EFFECT OF SEED - WEIGHT AND SEED - SIZE ON THE AVERAGE DRY MATTER PRODUCTION AND PERCENTAGE MOISTURE CONTENTS IN ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		LEAVES		SHOOT**		ROOT		TOTAL SEEDLING		SHOOT/ROOT DRY WT. RATIO
		A	B	A	B	A	B	A	B	
W - 1	Av.	0.5796	77.86	0.9028	65.22	1.1864	57.74	2.0892	60.06	0.7610
	S.E.	± 0.0216	± 2.74	± 0.0342	± 2.96	± 0.0404	± 2.78	± 0.0716	± 2.12	± 0.0212
W - 2	Av.	0.7384	80.18	1.2106	63.24	2.7166	56.12	3.9272	58.14	0.4456
	S.E.	± 0.0322	± 2.12	± 0.0416	± 2.44	± 0.0788	± 2.66	± 0.1022	± 2.74	± 0.0198
W - 3	Av.	0.5576	75.84	0.9014	61.92	1.8330	58.50	2.7344	59.58	0.4918
	S.E.	± 0.0324	± 2.96	± 0.0398	± 1.98	± 0.0616	± 2.28	± 0.0984	± 2.44	± 0.0202
W - 4	Av.	0.4316	79.52	0.7064	59.40	1.3024	57.78	2.0088	58.34	0.5424
	S.E.	± 0.0244	± 3.12	± 0.0276	± 2.04	± 0.0414	± 3.16	± 0.0764	± 1.98	± 0.0244
W - 5	Av.	0.4768	80.98	0.7882	61.64	1.4948	55.34	2.2830	57.36	0.5273
	S.E.	± 0.0216	± 3.44	± 0.0316	± 2.86	± 0.0572	± 2.94	± 0.0822	± 3.16	± 0.0216
W - 6	Av.	0.4576	78.06	0.7654	63.26	1.3510	53.24	2.1164	56.47	0.5665
	S.E.	± 0.0258	± 2.78	± 0.0298	± 3.12	± 0.0516	± 2.76	± 0.0822	± 2.88	± 0.0198
W - 7	Av.	0.3178	72.82	0.5228	66.84	0.5492	57.26	1.0720	61.56	0.9519
	S.E.	± 0.0196	± 3.16	± 0.0344	± 2.78	± 0.0244	± 3.44	± 0.0516	± 2.48	± 0.0412
W - 8	Av.	0.3654	77.26	0.5984	59.38	0.6480	59.56	1.2464	59.47	0.9235
	S.E.	± 0.0212	± 3.44	± 0.0316	± 2.66	± 0.0298	± 3.06	± 0.0442	± 3.60	± 0.0376
W - 9	Av.	0.3058	75.98	0.5830	63.52	0.6132	55.78	1.1962	59.30	0.9508
	S.E.	± 0.0216	± 3.44	± 0.0344	± 2.72	± 0.0316	± 2.98	± 0.0442	± 2.76	± 0.0444

* 5 Replicates of 5 plants each, ** Includes values of leaves

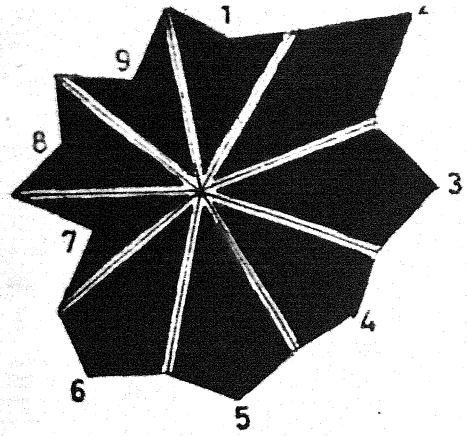
LEGENDS : Treatments = Please refer to Table - 6.1

Av. = Average, S.E. = Standard error, A = Average dry weight (g),

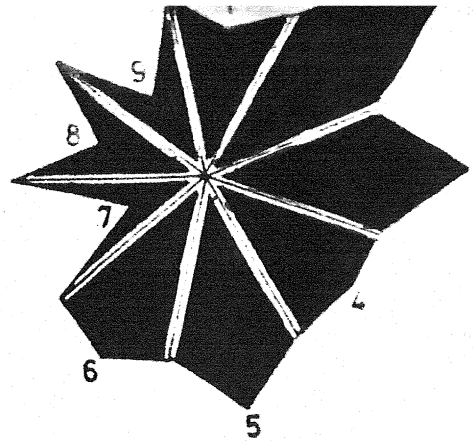
B = Percentage moisture contents

consisting usually of a green blade on a shoot and are concerned with photosynthesis and transpiration. The total average photosynthetic area of leaves present in a seedling of A.pendula, their average dry weights and the average percentage moisture contents offered by them differed considerably under different treatments. The maximum and the minimum values of ut supra parameters, as recorded in each of the experiments were as follows :

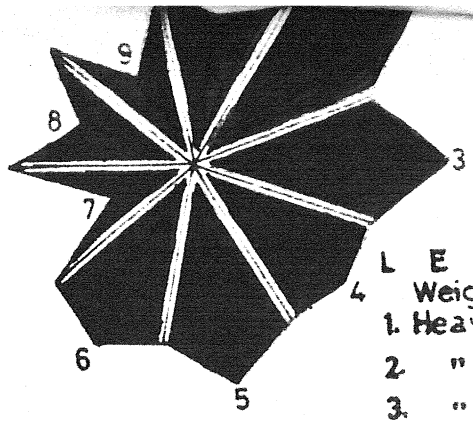
(i). Inorganic Fertilizers :- Photosynthetic area : 165.6 cm^2 in Nitrogen - 120 kg + Potassium - 40 kg/ha dose (23.03 % bounce) and 91.4 cm^2 in Phosphorus - 40 kg/ha dose (32.10 % drop) respectively, whereas, the control yielded 134.6 cm^2 of leaf area, (Table - 6.2.b). Biomass : g in Nitrogen - 120 kg/ha (26.25 % rise) and 0.5498 g in Phosphorus - 40 kg/ha (28.19 % fall) respectively as against 0.7656 g in the control (Table - 6.2.c). Moisture : 80.68 % in Nitrogen - 40 kg + Phosphorus - 20 kg + Potassium - 40 kg/ha (7.03 % increase) and 71.96 % in Nitrogen - 120 kg/ha (4.54 % decrease) respectively in contrast to 75.38 % moisture in the leaves of the seedlings under control (Table - 6.2.c).



SHOOT LENGTH



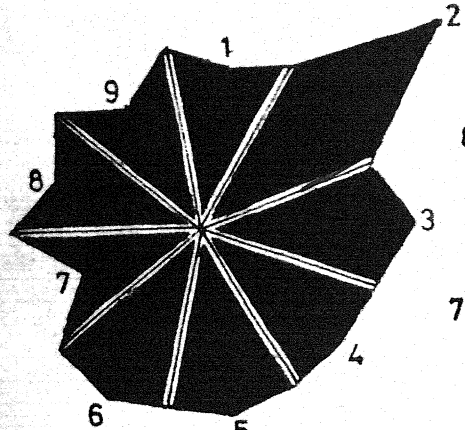
ROOT LENGTH



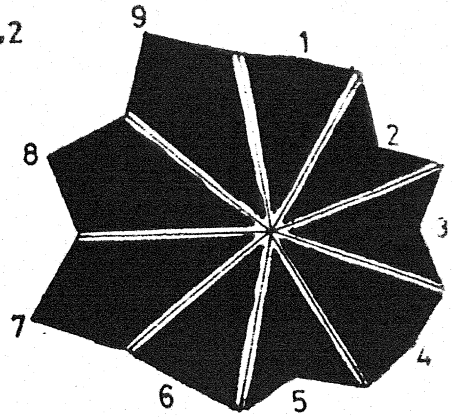
PLANT LENGTH

L E G E N D :

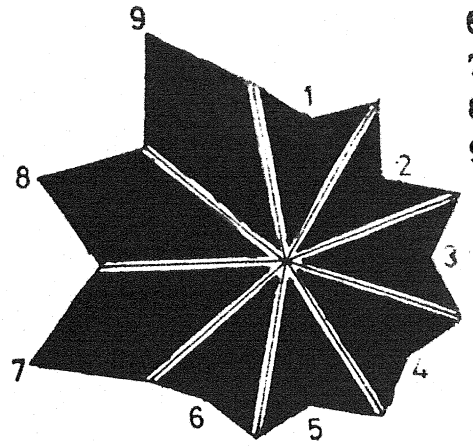
	Weight	& Size
1.	Heavy	Large
2.	"	Medium
3.	"	Small
4.	Medium	Large
5.	"	Medium
6.	"	Small
7.	Light	Large
8.	"	Medium
9.	"	Small



PHOTOSYNTHETIC AREA



SHOOT / ROOT
LENGTH RATIO



SHOOT / ROOT
DRY WEIGHT RATIO

FIG. 6.6 POLYDONIC DIAGRAMS DEPICTING THE EFFECT OF SEED WEIGHT AND SIZE ON THE GROWTH INCREMENT OF A. PENDULA SEEDLINGS. THE RADIUS OF THE CIRCLE IS PROPORTIONAL TO THE AVERAGE GROWTH VALUES. THE AREA OF THE BLACK QUADRILATERAL IS EQUAL TO THE GROWTH GAIN OF A PARTICULAR SEED WEIGHT AND SEED SIZE CATEGORY.

TABLE - 6.5.(a) EFFECT OF VARIOUS COMBINATIONS OF DIFFERENT SOIL COMPOSITIONS ON THE NUMBER AND TOTAL LENGTH (cm) OF SECONDARY ROOTS, AND COLLAR GIRTH (cm) OF ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		NUMBER OF SECONDARY ROOTS	LENGTH OF SECONDARY ROOTS	COLLAR CIRCUMFERENCE
S - 1 :	Av.	50.2	94.8	0.68
	S.E.	± 1.44	± 2.18	± 0.07
S - 2 :	Av.	23.2	64.0	0.68
	S.E.	± 1.16	± 1.24	± 0.08
S - 3 :	Av.	24.8	66.4	0.76
	S.E.	± 1.64	± 1.36	± 0.08
S - 4 :	Av.	26.2	68.6	0.68
	S.E.	± 1.98	± 2.08	± 0.04
S - 5 :	Av.	21.4	44.8	0.74
	S.E.	± 2.24	± 1.64	± 0.06
S - 6 :	Av.	22.2	65.4	0.74
	S.E.	± 1.36	± 1.96	± 0.08
S - 7 :	Av.	26.2	67.2	0.68
	S.E.	± 1.32	± 2.98	± 0.06
S - 8 :	Av.	20.8	48.2	0.76
	S.E.	± 2.44	± 1.44	± 0.07
S - 9 :	Av.	21.2	49.2	0.74
	S.E.	± 1.36	± 1.98	± 0.05
S - 10:	Av.	24.6	66.4	0.76
	S.E.	± 1.98	± 1.16	± 0.05
S - 11:	Av.	19.2	24.2	0.72
	S.E.	± 1.98	± 1.16	± 0.05
S - 12:	Av.	20.2	30.6	0.76
	S.E.	± 1.76	± 1.88	± 0.07

(Continue)

(Continued) (11)

S - 13 :	Av.	19.4	25.4	0.74
	S.E.	± 2.44	± 1.76	± 0.06
S - 14 :	Av.	20.4	29.6	0.74
	S.E.	± 1.16	± 1.48	± 0.06
S - 15 :	Av.	19.4	26.6	0.74
	S.E.	± 1.36	± 1.92	± 0.06
S - 16 :	Av.	19.8	44.0	0.74
	S.E.	± 1.68	± 1.44	± 0.06
S - 17 :	Av.	19.6	40.8	0.72
	S.E.	± 1.98	± 1.22	± 0.07
S - 18 :	Av.	20.8	43.6	0.76
	S.E.	± 1.44	± 1.32	± 0.06
S - 19 :	Av.	19.6	39.6	0.74
	S.E.	± 1.66	± 1.82	± 0.07
S - 20 :	Av.	21.2	28.6	0.74
	S.E.	± 1.98	± 1.64	± 0.06
S - 21 :	Av.	19.4	45.4	0.72
	S.E.	± 1.36	± 1.84	± 0.07
S - 22 :	Av.	19.4	26.2	0.70
	S.E.	± 1.44	± 1.42	± 0.07
S - 23 :	Av.	20.0	44.8	0.74
	S.E.	± 1.44	± 1.18	± 0.06
S - 24 :	Av.	20.4	43.6	0.72
	S.E.	± 1.36	± 2.10	± 0.08
S - 25 :	Av.	21.6	67.2	0.68
	S.E.	± 2.10	± 2.26	± 0.04

(Continue)

(Continued)

S - 26	Av.	20.2	41.6	0.68
	S.E.	± 1.66	± 2.60	± 0.05
S - 27	Av.	21.0	64.6	0.70
	S.E.	± 0.88	± 2.32	± 0.05
S - 28	Av.	26.0	68.0	0.72
	S.E.	± 1.98	± 1.84	± 0.05
S - 29	Av.	25.8	69.2	0.76
	S.E.	± 1.68	± 2.14	± 0.06
S - 30	Av.	23.4	49.6	0.76
	S.E.	± 1.44	± 1.56	± 0.06
S - 31	Av.	24.2	66.4	0.76
	S.E.	± 1.36	± 1.84	± 0.06
S - 32	Av.	23.2	47.8	0.74
	S.E.	± 1.92	± 1.56	± 0.05
S - 33	Av.	24.0	66.8	0.78
	S.E.	± 1.62	± 1.98	± 0.05
S - 34	Av.	21.4	44.2	0.72
	S.E.	± 1.34	± 1.66	± 0.06
S - 35	Av.	21.0	46.6	0.74
	S.E.	± 1.44	± 1.24	± 0.06

* 5 Replicates of 5 plants each

LEGENDS : Treatments = Please refer to Table - 6.1

Av. = Average, S.E. = Standard error

(ii). Growth Hormones :- Photosynthetic area : 170.2 cm^2 in 500 ppm/KN (22.80 % swell) and 121.4 cm^2 in 500 ppm/KN (12.41 % curtail) respectively as compared with 138.6 cm^2 in the control (Table - 6.3.b). Biomass: 1.2146 g (61.39 % increase) and 0.6044 g (19.69 % decrease) in the same respective hormonal sprayings as against 0.7526 g in the control (Table - 6.3.c). Moisture : 83.54 % in 100 ppm/GA (9.49 % profit) and 72.28 % in 100 ppm/IPA (5.28 % loss) respectively with regards to 76.30 % in the control.

(iii). Seed Polymorphism :- Photosynthetic area : 116.8 cm^2 in heavy weighted - medium sized seeds and 48.8 cm^2 in light weighted - small sized seeds (Table - 6.4.b). Biomass : 0.7384 g and 0.3058 in the same respective categories of weight and size classes (Table - 6.4.c). Moisture : 80.98 % in medium weighted - medium sized and 72.82 % in light weighted - large sized seeds respectively.

(iv). Soil Compositions :- Photosynthetic area : 152.4 cm^2 in a mixture of sand and black soil (3 : 1 ratio by volume) and 29.8 cm^2 in pure peat (Table - 6.5.b). Biomass : 0.9326 g in a mixture of sand, black and

TABLE - 6.5.(b) EFFECT OF VARIOUS COMBINATIONS OF DIFFERENT SOIL COMPOSITIONS ON THE AVERAGE GROWTH INCREMENT OF ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		PHOTOSYNTHETIC AREA (cm^2)	SHOOT LENGTH (cm)	ROOT LENGTH (cm)	TOTAL SEEDLING LENGTH (cm)	SHOOT/ROOT LENGTH RATIO
S - 1 :	Av.	134.2	19.42	60.44	79.86	0.3213
	S.E.	± 5.76	± 2.88	± 4.48	± 5.92	± 0.0314
S - 2 :	Av.	111.6	20.92	44.26	65.18	0.4727
	S.E.	± 5.18	± 1.24	± 3.36	± 3.36	± 0.0424
S - 3 :	Av.	152.4	30.84	58.66	89.50	0.5257
	S.E.	± 7.44	± 2.26	± 5.58	± 5.20	± 0.0112
S - 4 :	Av.	150.2	28.18	58.74	86.92	0.4797
	S.E.	± 7.66	± 3.12	± 3.72	± 4.74	± 0.0566
S - 5 :	Av.	84.8	17.62	32.66	50.28	0.5395
	S.E.	± 3.58	± 1.64	± 3.44	± 3.14	± 0.0598
S - 6 :	Av.	121.2	24.12	48.38	72.50	0.4986
	S.E.	± 6.44	± 2.12	± 3.92	± 6.44	± 0.0398
S - 7 :	Av.	139.8	28.46	55.78	84.04	0.5121
	S.E.	± 5.14	± 4.14	± 3.76	± 5.02	± 0.0416
S - 8 :	Av.	96.4	22.66	38.18	60.84	0.5935
	S.E.	± 3.22	± 1.24	± 2.34	± 3.16	± 0.0224
S - 9 :	Av.	104.8	21.18	42.66	63.84	0.4965
	S.E.	± 6.44	± 2.34	± 2.46	± 3.82	± 0.0516
S - 10:	Av.	124.4	29.42	49.88	79.30	0.5898
	S.E.	± 7.36	± 1.98	± 3.36	± 3.34	± 0.0398
S - 11:	Av.	29.8	11.34	11.46	22.80	+ 0.9895
	S.E.	± 1.46	± 1.12	± 0.74	± 1.22	± 0.0312

(Continue)

(Continued) (ii)

S - 12	Av.	51.4	15.72	20.12	35.84	0.7813
	S.E.	± 3.20	± 1.36	± 1.20	± 2.42	± 0.0312
S - 13	Av.	34.6	13.98	14.28	28.26	0.9790
	S.E.	± 3.82	± 1.24	± 1.72	± 1.64	± 0.0222
S - 14	Av.	49.2	14.26	19.66	33.92	0.7253
	S.E.	± 2.98	± 0.98	± 1.08	± 2.28	± 0.0264
S - 15	Av.	40.6	13.32	15.82	29.14	0.8419
	S.E.	± 3.64	± 1.16	± 1.04	± 1.22	± 0.0414
S - 16	Av.	73.8	16.58	30.18	46.76	0.5494
	S.E.	± 3.52	± 1.44	± 2.16	± 2.16	± 0.0396
S - 17	Av.	60.6	18.28	24.36	42.64	0.7504
	S.E.	± 2.44	± 1.84	± 1.98	± 2.36	± 0.0284
S - 18	Av.	78.2	17.02	31.84	48.86	0.5345
	S.E.	± 3.14	± 1.16	± 2.76	± 2.84	± 0.0472
S - 19	Av.	56.8	17.82	22.48	40.30	0.7927
	S.E.	± 3.36	± 1.02	± 1.42	± 2.56	± 0.0516
S - 20	Av.	44.8	11.84	18.32	30.16	0.6463
	S.E.	± 2.92	± 1.36	± 1.24	± 2.26	± 0.0516
S - 21	Av.	97.8	18.92	34.96	53.88	0.5412
	S.E.	± 3.44	± 0.98	± 1.84	± 2.08	± 0.0428
S - 22	Av.	42.2	12.26	16.68	28.94	0.7350
	S.E.	± 2.36	± 1.44	± 1.80	± 1.76	± 0.0416
S - 23	Av.	82.4	18.56	33.88	52.44	0.5478
	S.E.	± 3.94	± 1.96	± 2.12	± 3.88	± 0.0364
S - 24	Av.	69.4	16.34	27.84	44.18	0.5869
	S.E.	± 3.90	± 1.26	± 1.34	± 2.62	± 0.0342

(Continue)

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S - 25	Av.	111.4	23.84	46.14	69.98	0.5167
	S.E.	± 5.14	± 2.18	± 2.12	± 2.76	± 0.0296
S - 26	Av.	64.6	15.84	25.72	41.56	0.6159
	S.E.	± 3.26	± 0.96	± 1.22	± 2.26	± 0.0522
S - 27	Av.	114.8	23.20	45.64	68.84	0.5083
	S.E.	± 4.90	± 1.48	± 2.38	± 2.44	± 0.0416
S - 28	Av.	132.6	26.82	54.16	80.98	0.4952
	S.E.	± 5.22	± 2.02	± 3.56	± 4.96	± 0.0522
S - 29	Av.	138.8	27.14	54.74	81.88	0.4958
	S.E.	± 5.92	± 1.22	± 2.94	± 4.22	± 0.0488
S - 30	Av.	119.4	19.24	43.96	63.20	0.4377
	S.E.	± 4.16	± 1.44	± 1.94	± 3.22	± 0.0612
S - 31	Av.	125.6	28.84	50.38	79.22	0.5724
	S.E.	± 6.98	± 3.04	± 3.16	± 3.78	± 0.0516
S - 32	Av.	98.2	19.76	40.14	59.90	0.4323
	S.E.	± 7.18	± 1.22	± 2.24	± 3.14	± 0.0224
S - 33	Av.	123.8	29.26	48.74	78.00	0.6003
	S.E.	± 6.68	± 2.08	± 2.24	± 5.12	± 0.0410
S - 34	Av.	90.4	21.76	35.92	57.68	0.6058
	S.E.	± 4.34	± 2.72	± 2.24	± 3.36	± 0.0396
S - 35	Av.	91.6	22.06	36.58	58.64	0.6031
	S.E.	± 5.12	± 0.98	± 1.36	± 2.56	± 0.0410

* 5 Replicates of 5 plants each

LEGENDS : TREATMENTS = Please refer to Table - 6.1

Av. = Average , S.E. = Standard error

red soil (2 : 1 : 1 ratio by volume) and 0.3218 g in sole peat (Table - 6.5.c). Moisture : 83.58 % exclusively in black soil and 71.40 % in a mixture of sand and red soil (1 : 1 ratio by volume) respectively.

(v). Density :- Photosynthetic area : 117.8 cm^2 in a plant to plant distance of 20 cm and 68.8 cm^2 in an inbetween spacing of 5 cm (Table - 6.6.b). Biomass : 0.7944 g in a spacing of 25 cm and 0.5074 g in 5 cm gapings (Table - 6.6.c). Moisture : 82.64 % (20 cm spacing) and 78.10 % (5 cm spacing) respectively.

6.4.(d) T O T A L S E E D L I N G

Seedlings are the young plants raised from seeds. These are actually the infants of a plant species. The average total length, total biomass and the total moisture contents of A.pendula seedlings varied under different treatments. The maximum and the minimum average values of ut supra parameters, as recorded under each of the experimental trials, were as follows :

(i). Inorganic Fertilizers :- Length : 95.42 cm in Nitrogen - 120 kg + Potassium - 40 kg/ha (17.51 % gain) and 72.72 cm in Potassium - 20 kg/ha (8.53 % miss) as

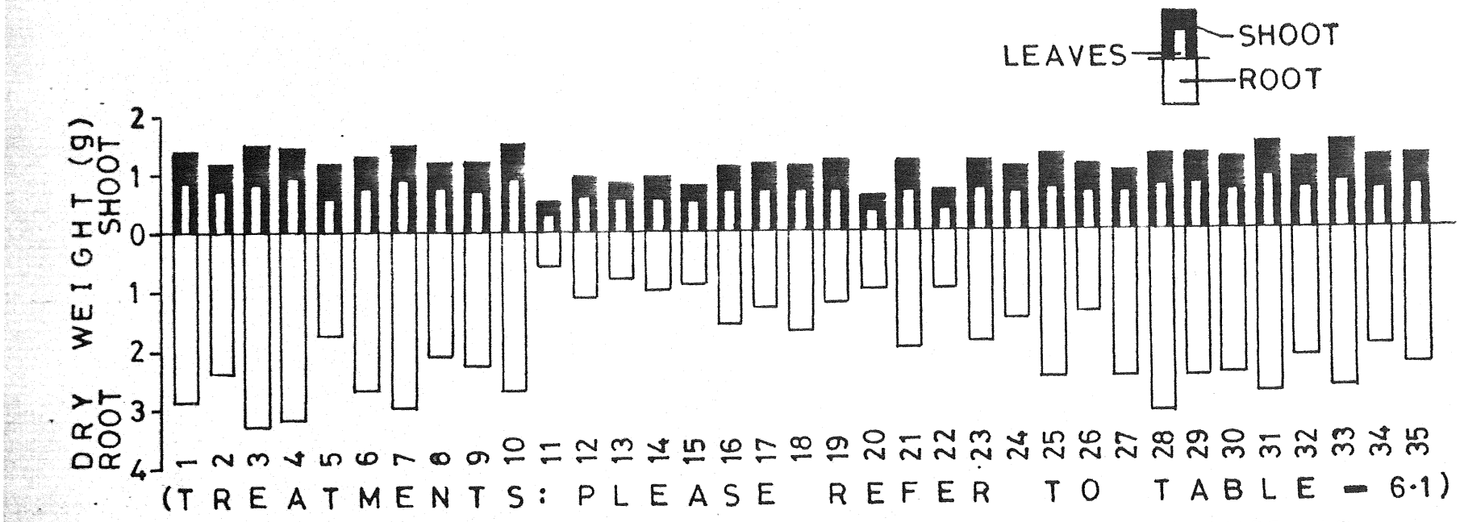


FIG. 6.7 AVERAGE DRY MATTER PRODUCTION IN A. PENDULA SEEDLINGS AS AFFECTED BY GROWING THEM IN DIFFERENT COMBINATIONS OF VARIOUS SOIL COMPOSITIONS.

TABLE - 6.5.(c) EFFECT OF VARIOUS COMPOSITIONS OF DIFFERENT POTTING MEDIA ON THE AVERAGE DRY MATTER PRODUCTION AND PERCENTAGE MOISTURE CONTENTS IN ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		LEAVES		SHOOT**		ROOT		TOTAL SEEDLING		SHOOT/ROOT DRY WT. RATIO
		A	B	A	B	A	B	A	B	
S - 1	Av.	0.8622	73.12	1.5824	58.52	3.3422	54.96	4.9246	56.84	0.4735
	S.E.	± 0.0726	± 4.54	± 0.0874	± 3.84	± 0.1292	± 4.14	± 0.3746	± 4.22	± 0.0156
S - 2	Av.	0.7692	77.84	1.2428	61.56	2.4448	58.54	3.6876	59.46	0.5083
	S.E.	± 0.0474	± 4.12	± 0.0722	± 4.66	± 0.1664	± 3.18	± 0.0822	± 3.98	± 0.0112
S - 3	Av.	0.9258	76.92	1.4496	60.86	2.8936	58.72	4.3432	59.36	0.5010
	S.E.	± 0.0664	± 3.66	± 0.0728	± 4.12	± 0.2526	± 4.62	± 0.3644	± 4.64	± 0.0126
S - 4	Av.	0.8634	81.64	1.4788	60.78	3.2346	59.86	4.7134	60.28	0.4572
	S.E.	± 0.0512	± 4.12	± 0.0948	± 3.92	± 0.2626	± 4.38	± 0.0246	± 3.24	± 0.0154
S - 5	Av.	0.6328	78992	1.1890	62.46	1.7984	55.92	2.9874	58.42	0.6611
	S.E.	± 0.0420	± 4.88	± 0.0364	± 4.48	± 0.0998	± 2.94	± 0.6548	± 3.60	± 0.0192
S - 6	Av.	0.8146	75.46	1.3412	64.34	2.7184	59.98	4.0596	61.76	0.4934
	S.E.	± 0.0364	± 3.24	± 0.0518	± 4.32	± 0.0812	± 3.86	± 0.3912	± 4.12	± 0.0164
S - 7	Av.	0.9162	71.40	1.5098	59.88	3.0824	58.26	4.5922	58.50	0.4898
	S.E.	± 0.0718	± 4.36	± 0.1012	± 3.72	± 0.4206	± 2.44	± 0.6022	± 3.64	± 0.0144
S - 8	Av.	0.7856	83.36	1.2722	64.92	2.1172	57.64	3.3894	59.94	0.6009
	S.E.	± 0.0522	± 4.22	± 0.1244	± 2.86	± 0.2148	± 3.96	± 0.1698	± 2.98	± 0.0192
S - 9	Av.	0.7284	80.08	1.2464	65.84	2.3842	59.78	3.6306	61.58	0.5228
	S.E.	± 0.0546	± 2.86	± 0.0718	± 4.94	± 0.2616	± 2.82	± 0.2464	± 4.40	± 0.0212
S - 10	Av.	0.9326	74.22	1.5696	61.36	2.7844	59.32	4.3540	60.24	0.5637
	S.E.	± 0.0546	± 2.86	± 0.0718	± 4.94	± 0.2616	± 2.82	± 0.2464	± 4.40	± 0.0212
S - 11	Av.	0.3218	78.86	0.5168	64.24	0.6588	58.56	1.1756	60.78	0.7845
	S.E.	± 0.0384	± 3.84	± 0.0298	± 4.86	± 0.1672	± 2.14	± 0.0812	± 4.58	± 0.0214

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S - 12	Av.	0.6062	80.84	0.9684	67.78	1.1274	60.94	2.0958	62.42	0.8590
	S.E.	± 0.0744	± 4.66	± 0.0924	± 4.86	± 0.1056	± 3.58	± 0.2694	± 4.06	± 0.0576
S - 13	Av.	0.5802	82.12	0.8722	68.94	0.8152	59.40	1.6874	63.26	1.0699
	S.E.	± 0.0512	± 3.76	± 0.0624	± 4.44	± 0.3124	± 3.72	± 0.1576	± 3.80	± 0.0512
S - 14	Av.	0.5758	79.96	0.9528	68.26	1.0948	56.78	2.0476	62.34	0.8703
	S.E.	± 0.0616	± 2.92	± 0.0912	± 3.82	± 0.2284	± 4.12	± 0.1844	± 2.98	± 0.0214
S - 15	Av.	0.5178	77.38	0.8322	62.54	0.8976	58.46	1.7298	59.64	0.9271
	S.E.	± 0.0464	± 3.44	± 0.0916	± 4.16	± 0.3168	± 3.44	± 0.2646	± 5.94	± 0.0464
S - 16	Av.	0.6922	81.46	1.1732	68.54	1.6756	60.98	2.8488	62.92	0.7002
	S.E.	± 0.0482	± 5.16	± 0.0774	± 3.44	± 0.2258	± 2.98	± 0.2152	± 4.76	± 0.0892
S - 17	Av.	0.7154	80.34	1.1926	67.38	1.3634	58.64	2.5560	63.16	0.8747
	S.E.	± 0.0692	± 3.44	± 0.0694	± 3.28	± 0.2144	± 3.84	± 0.1894	± 3.28	± 0.0564
S - 18	Av.	0.7018	76.68	1.1834	64.42	1.7758	57.66	2.9592	60.34	0.6664
	S.E.	± 0.0528	± 5.18	± 0.0788	± 3.92	± 0.4646	± 5.92	± 0.2816	± 4.76	± 0.0352
S - 19	Av.	0.7192	81.16	1.1906	68.24	1.2592	61.20	2.4498	63.98	0.9455
	S.E.	± 0.0884	± 3.12	± 0.1012	± 2.44	± 0.1012	± 3.12	± 0.2568	± 4.90	± 0.0612
S - 20	Av.	0.3668	83.58	0.6106	66.32	1.0252	61.56	1.6358	63.02	0.5956
	S.E.	± 0.0396	± 4.44	± 0.0522	± 3.96	± 0.0896	± 2.94	± 0.1898	± 3.42	± 0.0284
S - 21	Av.	0.7336	76.92	1.2216	67.04	1.9548	58.82	3.1764	62.56	0.6249
	S.E.	± 0.0712	± 3.96	± 0.0416	± 3.38	± 0.0922	± 4.36	± 0.1012	± 4.66	± 0.0226
S - 22	Av.	0.4352	81.80	0.7224	65.96	0.9536	58.56	1.6760	61.82	0.7576
	S.E.	± 0.0344	± 4.58	± 0.0544	± 3.82	± 0.0754	± 3.12	± 0.1656	± 3.82	± 0.0592
S - 23	Av.	0.7328	77.24	1.2148	68.26	1.8978	59.92	3.1126	62.24	0.6401
	S.E.	± 0.0442	± 4.12	± 0.1012	± 2.88	± 0.1676	± 4.68	± 0.4142	± 2.88	± 0.0284
S - 24	Av.	0.6712	76.52	1.1696	66.58	1.5526	57.16	2.7222	61.28	0.7533
	S.E.	± 0.0442	± 4.12	± 0.1012	± 2.88	± 0.1676	± 4.68	± 0.4142	± 2.88	± 0.0284
S - 25	Av.	0.7892	80.94	1.3076	67.72	2.5644	61.12	3.8720	63.04	0.5099
	S.E.	± 0.0684	± 3.82	± 0.1048	± 3.44	± 0.1166	± 2.94	± 0.2246	± 4.34	± 0.0144

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S - 26	Av.	0.6786	82.16	1.1616	68.82	1.4556	60.74	2.6172	62.44	0.7980
	S.E.	± 0.0412	± 4.34	± 0.1092	± 3.34	± 0.1898	± 3.56	± 0.1844	± 4.66	± 0.0192
S - 27	Av.	0.6562	78.92	1.0934	67.34	2.5466	58.88	3.6400	62.92	0.4294
	S.E.	± 0.0486	± 5.12	± 0.0822	± 2.92	± 0.2016	± 3.82	± 0.1532	± 3.74	± 0.0226
S - 28	Av.	0.7996	82.62	1.3446	68.44	3.1082	58.12	4.4528	63.26	0.4326
	S.E.	± 0.0532	± 3.44	± 0.0726	± 3.68	± 0.1948	± 3.48	± 0.3792	± 3.48	± 0.0248
S - 29	Av.	0.8342	77.54	1.3670	63.68	2.5384	56.36	3.9054	59.56	0.5385
	S.E.	± 0.0424	± 4.68	± 0.1092	± 4.12	± 0.2646	± 4.44	± 0.3484	± 4.34	± 0.0192
S - 30	Av.	0.7458	79.86	1.2346	61.48	2.4562	60.64	3.6908	60.92	0.5026
	S.E.	± 0.0512	± 3.92	± 0.0966	± 4.48	± 0.1594	± 3.86	± 0.2722	± 4.22	± 0.0384
S - 31	Av.	0.9074	81.58	1.5466	64.84	2.8038	60.48	4.3504	61.88	0.5516
	S.E.	± 0.0656	± 2.86	± 0.0874	± 4.44	± 0.2446	± 2.98	± 0.2644	± 3.62	± 0.0228
S - 32	Av.	0.7228	77.80	1.2388	66.34	2.2264	57.92	3.4652	62.14	0.5564
	S.E.	± 0.0522	± 4.32	± 0.1028	± 3.16	± 0.2164	± 3.84	± 0.1812	± 4.12	± 0.0244
S - 33	Av.	0.8494	79.72	1.5574	65.96	2.6978	58.84	4.2552	61.56	0.5773
	S.E.	± 0.0648	± 3.44	± 0.1156	± 3.92	± 0.1928	± 4.48	± 0.3476	± 4.74	± 0.0192
S - 34	Av.	0.7428	81.36	1.2532	66.28	2.0046	59.74	3.2578	62.34	0.6252
	S.E.	± 0.0546	± 3.92	± 0.0988	± 3.44	± 0.1144	± 2.98	± 0.3054	± 3.92	± 0.0216
S - 35	Av.	0.7536	80.64	1.2618	68.74	2.3658	58.26	3.6276	63.36	0.5334
	S.E.	0.0348	2.98	0.0876	2.86	0.2166	4.44	0.1958	4.84	0.0378

* 5 Replicates of 5 plants each

** Including values of leaves

LEGENDS : Treatments = Please refer to Table - 6.1

A = Average dry weight (g),

B = Percent moisture

against 79.50 cm in the control (Table - 6.2.b). Biomass : 4.8880 g in Nitrogen - 120 kg + Phosphorus - 40 kg + Potassium - 40 kg/ha (12.78 % expansion) and 3.6898 g in Pottasium - 20 kg/ha (14.87 % contraction) in relation to 4.3342 g in control.

(ii). Growth Hormones :- Length : 100.36 cm in 500 ppm/ IBA (24.18 % earning) and 67.64 cm in 500 ppm/COU (16.31 % spending) in contrast to 80.82 cm in control (Table - 6.3.b). Biomass : 5.0564 g and 3.9146 g in the same respective hormonal treatments. That were 15.37 % more and 10.68 % less respectively than that of control (4.3826 g). Moisture : 64.79 % in 10 ppm/GA (4.72 % up) and 55.98 % in 100 ppm/IAA (9.52 % down) with respect to 61.87 % in control (Table - 6.3.c).

(iii). Seed Polymorphism :- Length : 58.10 cm through heavy weighted - medium sized seeds and 16.10 cm through light weighted - large sized seeds (Table - 6.4.b). Biomass : 3.9272 g and 1.0720 g in the same respective categories of weight and size classes (Table - 6.4.c). Moisture : 61.56 % in light weighted - large sized seeds and 56.47 % in medium weighted - small sized seeds respectively.

(iv). Soil Compositions :- Length : 89.50 cm in a mixture

TABLE - 6.6(a) EFFECT OF DENSITY/(m^2) ON THE NUMBER AND TOTAL LENGTH (cm) OF SECONDARY ROOTS AND COLLAR GIRTH (cm) OF ANOGEISSUS PENDULA SEEDLINGS.*

TREATMENTS		NUMBER OF SEC. ROOTS	LENGTH OF SEC. ROOTS	COLLAR CIRCUMFERENCE
D - 1	Av.	11.20	32.48	0.48
	S.E.	± 0.48	± 2.36	± 0.02
D - 2	Av.	16.80	45.26	0.52
	S.E.	± 0.62	± 3.12	± 0.03
D - 3	Av.	28.40	88.24	0.68
	S.E.	± 0.98	± 3.38	± 0.04
D - 4	Av.	30.10	85.26	0.68
	S.E.	± 1.44	± 3.96	± 0.06
D - 5	Av.	29.60	87.58	0.68
	S.E.	± 1.76	± 3.54	± 0.04
D - 6	Av.	27.30	84.18	0.68
	S.E.	± 1.44	± 2.32	± 0.04
D - 7	Av.	27.40	77.82	0.68
	S.E.	± 1.06	± 3.76	± 0.06

* 5 Replicates of five plants each

LEGENDS : Treatments = Please refer to the Table - 6.1

Av. = Average, S.E. = Standard error

TABLE - 6.6.(b) EFFECT OF DENSITY / (m^2) ON THE AVERAGE GROWTH INCREMENT OF ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		PHOTOSYNTHETIC AREA (cm^2)	SHOOT LENGTH (cm)	ROOT LENGTH (cm)	TOTAL SEEDLING LENGTH (cm)	SHOOT/ROOT LENGTH RATIO
D - 1 :	Av.	68.8	8.36	12.06	20.42	0.6932
	S.E.	± 3.44	± 0.92	± 1.68	± 1.76	± 0.0218
D - 2 :	Av.	85.6	12.40	22.12	34.52	0.5606
	S.E.	± 3.88	± 0.98	± 2.04	± 2.16	± 0.0226
D - 3 :	Av.	102.2	19.02	37.86	56.88	0.5024
	S.E.	± 2.72	± 1.02	± 2.26	± 2.52	± 0.0198
D - 4 :	Av.	116.4	19.42	38.92	58.34	0.4990
	S.E.	± 4.14	± 1.88	± 3.02	± 2.68	± 0.0218
D - 5 :	Av.	117.6	19.26	40.16	59.26	0.4815
	S.E.	± 4.28	± 1.26	± 2.78	± 3.64	± 0.0222
D - 6 :	Av.	112.2	19.56	39.92	59.58	0.4888
	S.E.	± 3.82	± 1.84	± 2.08	± 3.16	± 0.0218
D - 7 :	Av.	110.2	19.46	40.06	59.52	0.4858
	S.E.	± 4.04	± 1.98	± 2.64	± 3.44	± 0.0246

* 5 Replicates of 5 plants each

LEGENDS : Treatments = Please refer to Table 6.1

Av. = Average

S.E. = Standard error

of sand and black soil (3 : 1 ratio by volume) and 22.80 cm in pure peat (Table - 6.5.b). Biomass : 4.9246 g and 1.1756 g in the same respective compositions of soils (Table - 6.5.c).

(v). Density :- Length : 59.58 cm (25 cm spacing) and 20.42 cm (5 cm spacing). Biomass : 3.8916 g and 2.2202 g in the same respective spacing (Table - 6.6b and 6.6.c). Moisture : 60.93 % and 55.03 % in 25 cm and 5 cm spacings respectively.

6.4.(e) S H O O T - R O O T R A T I O S

This ratio is usually calculated by dividing the length, fresh weight or more commonly the dry weight of shoots-formed, by the same parameter of the roots-formed during the growth period under consideration. The experiment-wise results indicate that the maximum and the minimum shoot - root ratios varied with different treatments as follows :

(i). Inorganic Fertilizers :- Length : 0.7453 in Nitrogen - 120 kg + Potassium - 20 kg/ha and 0.3319 in Phosphorus - 40 kg/ha respectively (Table - 6.2.b). That were 58.24 % high and 29.55 % low over the control (0.4711). Biomass : 0.6083 and 0.2474 in the same respective fertilizer

TABLE - 6.6.(a) EFFECT OF DENSITY / (m^2) ON THE AVERAGE DRY MATTER PRODUCTION AND PERCENTAGE MOISTURE CONTENTS IN ANOGEISSUS PENDULA SEEDLINGS*.

TREATMENTS		LEAVES		SHOOT		ROOT		TOTAL SEEDLING**		SHOOT/ ROOT DRY WT. RATIO
		A	B	A	B	A	B	A	B	
D - 1	Av.	0.5074	78.10	0.9578	58.84	1.2624	51.16	2.2202	55.03	0.7587
	S.E.	± 0.0768	± 3.22	± 0.0616	± 3.66	± 0.0784	± 2.98	± 0.1052	± 1.84	± 0.0308
D - 2	Av.	0.5982	78.24	1.0202	61.32	1.3214	52.28	2.8416	55.97	0.5601
	S.E.	± 0.0324	± 3.64	± 0.0494	± 2.98	± 0.1066	± 3.16	± 0.1642	± 2.92	± 0.0218
D - 3	Av.	0.6750	78.76	1.2538	65.14	2.5356	53.48	3.7894	58.12	0.4945
	S.E.	± 0.0444	± 2.98	± 0.0648	± 2.48	± 0.1154	± 2.44	± 0.7818	± 1.56	± 0.0174
D - 4	Av.	0.7898	79.28	1.2644	59.84	2.6202	59.22	3.8846	59.42	0.4826
	S.E.	± 0.0426	± 3.12	± 0.1182	± 2.76	± 0.1864	± 3.16	± 0.5612	± 2.04	± 0.0254
D - 5	Av.	0.7866	82.64	1.2596	66.94	2.5988	57.16	3.8584	60.93	0.4847
	S.E.	± 0.0226	± 3.58	± 0.0916	± 2.16	± 0.2062	± 2.58	± 0.1894	± 2.80	± 0.0122
D - 6	Av.	0.7944	80.64	1.2734	60.28	2.6282	57.94	3.8916	59.73	0.4807
	S.E.	± 0.0486	± 2.68	± 0.1002	± 2.84	± 0.1986	± 2.48	± 0.2116	± 2.64	± 0.0256
D - 7	Av.	0.7576	79.12	1.2606	64.74	2.5720	58.04	3.8326	60.16	0.4901
	S.E.	± 0.0208	± 2.98	± 0.0644	± 2.84	± 0.1648	± 2.80	± 0.1892	± 1.98	± 0.0216

* 5 Replicates of 5 plants each

** Including values of leaves

LEGENDS : Treatments = See Table 6.1

A = Average dry matter (g)

B = Percent moisture

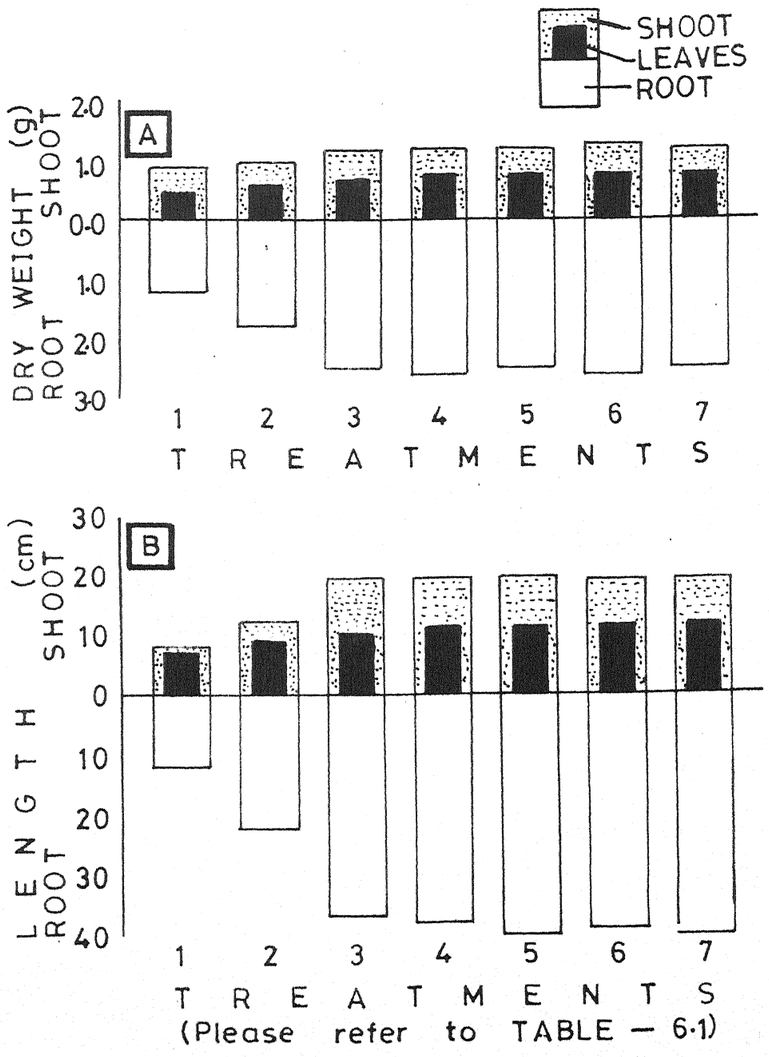
treatments with 37.44 % more and 44.10 % less than that of the control 0.4426 (Table - 6.2.c).

(ii). Growth Hormones :- Length : 0.6845 (42.22 % profit) in 500 ppm/IBA and 0.3547 (26.30 % loss) in 100 ppm/COU with respect to 0.4813 in the control (Table - 6.3.b). Biomass : 0.6941 in 500 ppm/AN (53.53 % bounce) and 0.4208 in 100 ppm/GA (6.92 % drop) as against 0.4521 in the control (Table - 6.3.c).

(iii). Seed Polymorphism :- Length : 1.0588 in light weighted - large sized seeds and 0.5602 in heavy weighted - medium sized seeds (Table - 6.4.b). Biomass : 0.9519 and 0.4456 in the same respective categories of weight and size classes (Table - 6.4.c).

(iv). Soil Compositions :- Length : 0.9895 in pure peat and 0.3213 in sole sand (Table - 6.5.b). Biomass 1.0699 in a mixture of peat and black soil (3 : 1 ratio by volume) and 0.4294 in a mixture of black soil and red soil (1 : 1 ratio by volume).

(v). Density :- Length : 0.6932 in plant to plant spacing of 5 cm and 0.4815 in an inbetween distance of 20 cm (Table 6.6.b). Biomass : 0.7587 in 5 cm spacing



(Please refer to TABLE — 6·1)

FIG. 6·8 EFFECT OF SPACING TRIALS ON THE MEAN BIOMASS BENEFIT-(A), AND THE GROWTH GAINS-(B), IN A. PENDULA SEEDLINGS.

trials and 0.4307 in 25 cm spacing treatment respectively (Table - 6.6.c).

6.5 I N T E R P R E T A T I O N S

IN a forest ecosystem, estimation of dry matter production by tree and tree seedlings and its distribution into the stem wood are of prime importance. In view of the rising demand of wood, it is imperative that the forest resources be maximised from the land devoted to forestry[292] Dry matter production is the key function in the ecological and sociological life of plant[64]. The determination of dry matter production by the plants always constitutes the basis for further studies in production ecology[213].

Growth is affected by the factors which affect the activity of protoplasm. It is affected by a large number of factors both environmental and physiological. Physiological factors may include absorption of water, minerals, photosynthesis, respiration, enzyme activity, hormone regulations etc., whereas, environmental factors may comprise of both climatic and bio-edaphic influences.

sola va sang die that variations in certain

environmental factors may be reflected in seedling size. A greater root growth of seedlings promotes the chances of survival of tree seedlings. The environment to which the roots are exposed is usually very different from that which the aerial organs of plants encounter. Because of the reciprocal influences between roots and tops of a plant, effect of any environmental factor on the development or physiological processes of the roots almost invariably will be reflected in the behaviour of the aerial organs, and vice-versa. Hence, a number of investigations have been made on the so called shoot : root ratios in plants. The shoot-root ratio is influenced by reciprocal correlative influences between the axial parts of a plant and its roots. The kind and magnitude of these correlative effects depend largely upon the environmental conditions to which the plant is exposed.

The plant growth is controlled by interaction of hereditary and environmental conditions[197]. In a particular set of environment, it is the capacity of the plant which is responsible for better growth. It has been observed throughout the globe that the initially induced differences in the relative growth

rates continue to widen throughout the life of a tree crop and such increases result in a substantial reduction in the length of rotation required to achieve a specified volume[46].

Forests are complex environments in which the seedling growth of its constituent species may be limited by several factors. Of these the nutrient supply is the easiest to alter by forest management practices. The study on such information will be useful not only in predicting successional patterns but also in developing cultural practice for stimulating growth of planted or natural 'Kardhai' seedlings on forested sites.

The genetic and environmental factors involved in plant growth is more basic than the supply of elements of which plant matter itself is constituted. The general relationship in which growth increases with th supply from deficient to optimum and thence to luxury levels much depends on the relative balance among elements within plant tissues. In forestry, mineral nutrition is especially significant because nutrient regime is one of the principal environmental factors over which, within economic possibility, some degree of control can be exercised[259].

Ad rem, the supplementation of soil nutrient levels in this study with nitrogen fertilizers resulted in development of considerable vertical structure. Additional supplementation with P or K or P + K, however, did not alter this response appreciably suggesting these two elements were not growth limiting in this trial. The general effect of nitrogen fertilizer on the A.pendula seedlings was to produce more leaves which presumably had a greater photosynthetic potential as indicated by increase in the dry weight and shoot-root ratio as well.

The reduced response to P and nearly the no response to K may reflect the semiarid nature of the local climate. The principal growth response was to nitrogen. The response in NP treatment indicate that N-addition resulted in increased P requirement in rapidly growing seedlings and this demand could not be satisfied from native P reserves. Stimulation of microbial activity with addition of N, in combination with soil organic matter, may have resulted in immobilisation of P by soil microbes for growth. The generally improved rate of soil biological activity could also be manifested in increased availability of other essential elements not added in the fertilizer treatments.

The rate of N absorbed seems to be proportional to the concentration of availabe N in the root zone which might have affected the rate of growth of A.pendula seedling; this in turn might have affected the rate of root development and, therefore, further N absorption. The greater the supply of N in the soil, the greater was the ratio of aerial dry matter growth to root growth. A shortage of N, therefore, restricsed the shoot growth to a greater extent than roots.

Increase in shoot to root ratio in response to added nitrogen is a result of differential growth response of shoot and root and has been observed in a multitude of plant species by a host of workers[287, 325, 374, 478].

Excess nitrate uptake by the plant may be chemically reduced and combined with free carbohydrates to form amino compounds in the shoots, consequently the roots may be restricted in their growth due to the lack of carbohydrate translocation from the shoots. At low levels of nitrogen supply, roots are stimulated to grow more than shoots which increases the translocation of carbohydrates to the root. Roots take up nitrate readily at any stage of growth and excess nitrate can accumulate within plants anytime during vegetative growth[163].

The forms of P in soil from native and fertilizer sources are important primarily with regard to their availability to plants. The amount of P uptake by plant roots is usually in direct proportion to root surface concentration of P. Soil texture can influence the relative effectiveness of P fertilizer through soil diffusion rate, rate of chemical reaction, and the reaction products formed. The indirect effects of soil texture on soil moisture and temperature may be equally as important as the direct effects[288].

K occurs in soils in water soluble, exchangeable non-exchangeable or fixed and mineral forms. Of these, water soluble and exchangeable forms of K are readily available to plants. Potassium is known to be contained in the process of assimilation and conversion of CO_2 into carbohydrates, in the transpiration of water and in the movement of carbohydrates from leaf to storage organs. There is also an important connection between the potassium and nitrogen in the leaf, nitrogen promotes leaf growth whilst potassium is responsible for leaf efficiency[420].

The present findings with growth hormones indicate that there is a possibility to increase the

growth of A.pendula seedlings by judicious application of Indole butyric acid and the Gibberellic acid in the nursery.

Different cells of multicellular organisms possess the same complement of genes. The most conspicuous forces participating in the control of gene action are a complex system of chemical messengers called hormones or regulatory molecules. Hormones regulate the organism at a variety of levels, ranging from responses to the external environment, growth, maturation and physiological homeostasis to cellular differentiation and biochemical modulations.

Inspection of the problem of how a hormone at very low concentration levels can exert very large physiological effects leads one naturally to the deduction that any mechanism of action must involve a large amplification effect. In bringing about its action the hormone can be expected to exert an influence on some process that alters a large number of other molecules[209].

Indole butyric acid was the most effective auxin in stimulating the maximum amount of growth in A.pendula seedlings. It seems to exert its growth

promoting effects relatively in high degree of control of cellular growth and elongation. Kinetin (KN), was not at all effective either in stimulating or retarding the growth of A.pendula seedlings. Coumarin and Maleic Hydrazide, both of them inhibited the growth of seedlings at all levels of concentrations affecting the shoot and very often the roots as well. Increased concentrations of these two synthetic growth regulators produced dwarfening of the seedlings. However, the effects of Gibberellic acid was proxime accessit after IBA in promoting growth in the present study.

GA might have exerted its physiological effects by altering the auxin status of the A.pendula seedlings. This alteration might have increased the auxin level in two of the either ways : by decreasing the rate of auxin destruction and or by increasing the rate of endogenous auxin production. A possible mode of action of GA seems that it might have acted at the gene level to cause de-repression of specific genes. The activated genes by producing new enzymes might have brought about the observed morphogenetic changes in Kardhai seedlings. The idea that GA acts at the gene level is especially convincing, considering the diversity of gibberellins in plants.

Though plant part weights and their ratios are determined mainly by heredity and age their modification by the environment is of silvicultural importance, especially during the seedling stage when plants are particularly sensitive to site characteristics. Soil and vegetation are interdependent basic resources having a great bearing on the environment. Characterization of their inter relationship is important for maximising the productivity from the limited land resources. The study described here was designed to determine how the nursery acquired shoot and root habits of A.pendula seedlings are modified by soil characters after transplanting them.

It is clear from the results that potting mixtures other than sand and red soil depressed height increments. Drainage, aeration and biological processes possibly became unfavourable. Increasing amount of clay was found to progressively retard growth. This is believed to be due to the poor aeration by high clay contents of the soil. Dry weights of shoot were also similarly affected. It seems reasonable that since high clay contents resulted in nearly water logging conditions, it might have inhibited the root development

of the seedlings of Kardhai. It was, post hoc, not surprising to notice that the poorest height increments were mainly derived from the potting media rich in organic contents.

The ability of the plant to utilize all available moisture is usually of primary importance and this largely depends on the root system. Soil structure has more influence on water holding capacity than the texture. Improved aeration seems to be a result of better soil structure which in turn might have resulted in a healthier and more vigorous root system.

The variation in the height growth patterns of A. pendula seedlings grown in different soil compositions might be due to the variations in their rooting patterns. Increase of height growth in A_3C_1 soil mixtures i.e., three part sand and one part black soil represented ease not only in the rooting of the seedlings, but in quick and more absorbtion of the available nutrient resources as well in order to attain the maximum height growth and dry matter increments.

The variation in shoot-root ratios might have influenced by the differences in available soil water

content : a relatively low soil water content and adequate soil aeration favoured relatively low S/R ratios, whereas, the opposite conditions favoured relatively high ones. Inadequate soil aeration resulted in a reduction in the root growth and lead to an increased S/R ratio.

It is usually desirable to make the most economical use of the nursery space. Thus, in order to standarize nursery techniques of 'Kardhai", the determination of optimum spacing pattern becomes all the more significant. Experiments were conducted accordingly to work out the growth behaviour of A.pendula seedlings as influenced by the different spacing trials.

The variations in biomass accumulation in A. pendula seedlings differed in different spacing with similar deviations in their average height and diameter. It seems that higher density of A.pendula seedlings, no doubt have resulted in competition among themselves for drawing their nutrients from a common pool with limited supply. This population stress might have increased the competition resulting in differences in rooting behaviour of the seedlings of 'Kardhai' .

Competition is essentially a decrease in the amount of water, nutrients or light available for each individuals which make similar demands upon the same supply at the same time. When groups of seedlings, especially of the same species, are closely spaced, competition begins almost immediately.

In A.pendula with the increase in the size of individuals, the demands might have correspondingly become greater causing increased competition which might have resulted in the suppression of growth. The effects of several factors for which plants ordinarily compete viz., water, light and nutrients, are almost always so integrated that they can be determined only under controlled conditions where all but one are eliminated.

However, during initial establishment phase, the low density of A.pendula seedlings was not exerting any of the said competition among themselves. Hence, the optimum density at which there was maximum utilisation of the available space with the minimum risk of competition among the seedlings seems to be $100/m^2$ i.e., the spacing of 10 x 10 cm from plant to plant.

There may be a close association between seed

size & weight and the seedling vigour. Shoot and root length of A.pendula seedlings increased with the increase in seed weight. This may be due to the greater amount of food reserves contained in the seed. However, an unusual behaviour in growth was noticed whereby the medium sized seeds gave healthy seedlings as compared to the large and small sized seeds. This could be ascribed to the slow activation of the metabolites in case of larger and smaller seeds due to hormonal or other disturbances during early phase of seedling emergence and their establishment.

Medium sized seeds were not always the best producing the vigourous seedlings of A.pendula . Weight of the seed was also equally important. Medium size coupled with heavy weight of the seed was the best. Greater embryonic capital and the greater absolute growth rate of the A.pendula seedlings were significantly proportional only with the medium size of the seeds. Seed weight of 'Kardhai' is likely to be important when a group of seeds of contrasting sizes are sown together and a struggle for existence develops between them.

Morphological characteristics of A.pendula seedlings relative to the weight of the seed used generally agreed with those of Pinus roxburghii[86], Pinus monticolinum[152], Pinus coccarpa[174] and many others. However, the behaviour of A.pendula seed size was parallel with that of Pinus caribaea, P.coccarpa and P.roxburghii[131] all of which showed best response of their seedlings with medium sized seed.

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C H A P T E R - VII

FRAMING OF THE ROOT-BUCKER

C H A P T E R - VII

F R A M I N G O F T H E R O O T - S U C K E R

7.1 P R E M I S E

ROOTS fulfil a number of roles besides absorption and that their morphology varies widely depending upon the part they play in the life of a plant. When the shoots arise from the roots they are called 'ROOT-SUCKERS' or in other words, "A sucker is a shoot arising below-ground"[463]. They may occur naturally or may be induced by felling the parent tree or by inflicting injury to the roots. Thus, they are a ready mean of propagation.

Though Troup[458] was able to recognise and has also informed about the occurrance of natural regeneration through root-suckers in Anogeissus pendula trees, but, till date details were not available on the know-how of them. This led to confusion among several workers directly or indirectly connected with 'Kardhai' plant. It all happened due to inability and the difficulties arising in identifying and locating the root suckers of Anogeissus pendula in Nature. However, in this presents, the author has tried to develope a a clear structure of the so-called faint picture of 'Kardhai' suckers.

7.2 REVIEW OF LITERATURE

In Anogeissus pendula, the presence of root-suckers was reported by Troup[450]. Prior to Troup, the list of Indian trees which reproduce themselves by root-shoots, commonly known as root-suckers, did not include A.pendula as a sucker producing tree[215, 351]. After Troup, several other scientists and forest ecologists working especially with A.pendula reported from time to time that root-suckers were either not present in it or were very difficult to observe them in nature[3, 28, 49, 225]. In 1951. S.P.Bhargava, the then W.P.O., Indore, even went to an extent to say, "Detailed observations on root-suckers of Kardhai (A.pendula) yet remains to be recorded"[49].

On the other hand, propagation of 'Kardhai' by means of runners was observed in Jhalawar division of Rajasthan while suspecting hybrid varieties of A.pendula x A.latifolia[7]. Root-grafts of 'Dhokra'(A.pendula) and root-grafts of other plant species combining with 'Dhokra' without any union by them has also been observed[8]. Recently, coalition of roots in between the root branches of the same parent trees of A.pendula was noticed by the author[366].

Thus, details are not available in the literature to enable one to observe or to locate the root suckers of 'Kardhai' in nature. Hence, this very important aspect has been

included in the present study to unveil the facts of root-suckers in A.pendula.

7.3. M A T E R I A L A N D M E T H O D

The present study was conducted in three forest blocks, ut infr. :

(1). Chandpura,

(2). Laxmanpura, and

(3). Nayakhera

Hereafter, these forests are known as S-I, S-II and S-III respectively. Details of these forests are provided in Chapter-II.

Roots were excavated around isolated trees of A.pendula in all the three sites separately. Area, where stocking of 'Kardhai' was not dense, were selected for digging. Pending operations like climber cutting and removal of unwanted growths around the parent tree were done prior to digging. The excavated tangled roots were very keenly observed for sprouting into suckers. Whenever any sucker was encountered, its all morphological details were measured and recorded. In all, 50 sucker-producing trees of 'Kardhai' were recorded i.e., 20 in Chandpura (10 on declivity and 5 each on plateau and base), and 15 each in Laxmanpura and Nayakhera (5 each on declivity, plateau and base). Detailed measurements of only the dominating sucker per parent tree were recorded.

7.4 O B S E R V A T I O N S

FOLLOWING nine morphological parameters were measured on plateau (P-I), declivity (P-II) and base (P-III) in each of the three forest blocks :

(1). Girth (gbh) of the parent-tree sprouting sucker.

(2). Approximate height of the parent-tree.

(3). Circumference of the parent-root sprouting sucker.

(4). Soil depth at which the sucker sprouted from the root.

(5). Distance of the sucker from trunk-base of the parent-tree.

(6). Collar girth of the sucker.

(7). Height of the sucker-generated culm.

(8). Number of secondary roots present in the sucker.

(9). Total number of suckers produced by the parent-tree.

Details of all the said parameters were tabulated and after careful analysis are presented in Table - 7.1 and 7.2. These observations are based on intensive exploration of the area. Regular field trips, digging and the excavation of roots made possible to understand the structure, distribution

TABLE - 7.1 MORPHOLOGICAL DETAILS OF THE PARENT TREES, SUCKERS AND THE SUCKER - GENERATED CULMS OF *ANOGEISSUS PENDULA* IN RELATION TO THREE DIFFERENT SITES AND THEIR TOPOGRAPHY.

SITES & TOPOGRAPHY		MORPHOLOGICAL PARAMETERS								
		M-I	M-II	M-III	M-IV	M-V	M-VI	M-VII	M-VIII	M-IX
CHANDPURA :										
TOP :	Av.	0.49	6.00	0.15	0.15	0.26	0.11	2.25	12.2	4.4
	S.E.	± 0.056	± 0.792	± 0.014	± 0.022	± 0.104	± 0.018	± 0.418	± 1.16	± 0.68
	Max.	0.71	9.00	0.18	0.26	0.68	0.13	5.00	15.0	6.0
	Min.	0.41	4.50	0.10	0.07	0.13	0.08	0.75	10.0	2.0
SLOPE :	Av.	0.32	3.65	0.13	0.12	0.21	0.14	1.87	14.1	6.0
	S.E.	± 0.018	± 0.130	± 0.012	± 0.016	± 0.028	± 0.032	± 0.224	± 0.86	± 0.52
	Max.	0.40	4.00	0.21	0.20	0.41	0.41	2.50	17.0	8.0
	Min.	0.26	3.00	0.08	0.05	0.12	0.08	0.15	9.0	3.0
BASE :	Av.	0.79	8.38	0.25	0.30	0.63	0.30	3.00	9.7	1.6
	S.E.	± 0.102	± 1.248	± 0.024	± 0.130	± 0.294	± 0.082	± 0.976	± 1.26	± 0.24
	Max.	0.98	11.00	0.31	0.80	1.77	0.62	6.50	13.0	2.0
	Min.	0.51	6.00	0.18	0.09	0.10	0.18	1.00	7.0	1.0
LALMANPURA:										
TOP :	Av.	0.35	4.10	0.12	0.09	0.20	0.12	1.90	12.2	3.2
	S.E.	± 0.022	± 0.244	± 0.016	± 0.034	± 0.038	± 0.034	± 0.292	± 0.50	± 0.58
	Max.	0.41	5.00	0.15	0.23	0.31	0.26	3.00	14.0	4.0
	Min.	0.31	3.50	0.08	0.05	0.09	0.07	1.50	11.0	1.0
SLOPE :	Av.	0.27	3.50	0.14	0.07	0.20	0.09	1.80	17.0	5.4
	S.E.	± 0.044	± 0.158	± 0.014	± 0.018	± 0.042	± 0.018	± 0.122	± 0.66	± 0.24
	Max.	0.28	4.00	0.18	0.16	0.35	0.11	2.00	19.0	6.0
	Min.	0.26	3.00	0.10	0.04	0.10	0.07	1.50	15.0	2.0

(Contd

(Continued)

BASE :	Av.	0.49	5.60	0.18	0.13	0.20	0.14	2.30	8.4	2.0
	S.E.	± 0.092	± 0.914	± 0.026	± 0.014	± 0.040	± 0.028	± 0.464	± 0.4	± 0.32
	Max.	0.76	8.50	0.26	0.21	0.32	0.25	3.50	9.0	3.0
	Min.	0.32	4.00	0.11	0.08	0.10	0.09	1.00	7.0	1.0
NAYAKHERA :										
TOP :	Av.	0.37	4.20	0.15	0.07	0.19	0.11	1.60	9.8	2.8
	S.E.	± 0.028	± 0.254	± 0.026	± 0.012	± 0.036	± 0.012	± 0.430	± 0.38	± 0.36
	Max.	0.44	5.00	0.24	0.11	0.31	0.15	3.00	11.0	4.0
	Min.	0.31	3.50	0.10	0.05	0.10	0.09	0.50	9.0	2.0
SLOPE :	Av.	0.27	3.20	0.12	0.06	0.16	0.10	1.90	16.4	5.2
	S.E.	± 0.026	± 0.254	± 0.018	± 0.010	± 0.030	± 0.008	± 0.186	± 0.68	± 0.36
	Max.	0.29	4.00	0.15	0.10	0.25	0.12	2.50	18.0	6.0
	Min.	0.26	2.50	0.10	0.05	0.08	0.07	1.50	14.0	2.0
BASE :	Av.	0.48	5.20	0.16	0.08	0.12	0.13	1.40	10.4	2.0
	S.E.	± 0.072	± 0.736	± 0.030	± 0.018	± 0.018	± 0.024	± 0.188	± 0.82	± 0.32
	Max.	0.62	7.00	0.24	0.15	0.15	0.21	2.00	13.0	3.0
	Min.	0.26	3.00	0.08	0.05	0.05	0.08	1.00	8.0	1.0

LEGENDS : M-I = Girth of the parent-tree sprouting sucker (m), M-II = Approximate height of the parent tree (m), M-III = Circumference (m) of the parent-root sprouting sucker, M-IV = Soil depth (m) at which the sucker sprouts from the root, M-V = Distance of the sucker (m) from trunk base of the parent-tree, M-VI = Collar-girth (m) of the root sucker, M-VII = Height of the sucker-generated culm, M-VIII = Numbers of secondary roots present in the sucker, M-IX = Total number of suckers present in a parent-tree.
Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

and the method of sprouting of the sucker in *A. pendula*.

Marked variations in number, dimensions and the mode of sprouting were observed and recorded in the parent-trees, suckers and the sucker-generated culms in relation to topography and the sites. Generally declivity or slope had a greater number of sucker-generated plants per parent tree as compared to that on plateau and the base. On an average, the number of suckers per parent-tree on slope were 5.15 whereas on plateau they were 3.46 and on base 1.86. Site-wise, it was more than four suckers per parent tree in Chandpura (4.5 suckers/tree) and nearly three in both, Laxmanpura (3.13 suckers/tree) and the Nayakhera (2.93 suckers/tree) forests. Individually, a maximum of 8 suckers/tree were noticed in Chandpura. Collectively, the overall average of all the three sites was 3.77 suckers/tree.

Girth of the parent-tree, parent-root and the sucker was of considerable importance. The cumulative average-girth (gbh) of parent-tree, including all the three sites, was 42.6 cm, whereas, the average values for each of the three sites, as calculated on the basis of observations, were - 48.2 cm/Chandpura, 37.5 cm/Nayakhera and 36.7 cm/Laxmanpura. Site-wise, maximum and minimum values for girth of the parent tree was - 98 cm/base and 26 cm/slope respectively in Chandpura; 76 cm/base and 26 cm/slope respectively in Laxmanpura and 62 cm/base and 26 cm/both base & slope respectively in Nayakhera. Average gbh

of parent-trees, in relation to topography was - 40.2 cm, 29.7 cm and 58.7 cm on top, slope and the base respectively.

Minimum circumferences of the parent-root, which produced sucker, were observed on top/Laxmanpura, slope/Chandpura and base/Nayakhera with uniform 8 cm of girth in each of the three sites, whereas, the maximum values for circumferences of parent-roots were 31 cm/base, 26 cm/base and 28 cm/both base & top in Chandpura, Laxmanpura and Nayakhera respectively. The average circumferences of parent-roots sprouting sucker were 16.5 cm/Chandpura and 14.6 cm in both, Laxmanpura and the Nayakhera blocks. In relation to topography, the average values of parent-root girth were 19.7 cm, 14.0 cm and 13.1 cm on base, top and the slope respectively. On an overall assessment, the collective average of the circumference of parent-roots was 15.5 cm.

Regarding collar-girth of the sprouted sucker, an overall collective average, as calculated, was 14.3 cm. Site-wise, the minimum values of collar-girth, as recorded, were : 8 cm/Chandpura on both,top and the slope; 7 cm/Laxmanpura on both, top and the slope and 7 cm/Nayakhera on slope. The maximum values of collar-girth had large, were : 62 cm/ Chandpura on base; 26 cm/Laxmanpura on top (Plate - 24) and 21 cm/Nayakhera on base. Average values of collar-girth in relation to topography were 19.1 cm/base, 11.5 cm/slope and

11.4 cm/top, whereas, the average values in relation to sites were : 17.2 cm, 11.7 cm and 11.2 cm in Chandpura, Laxmanpura and the Nayakhera blocks respectively.

The average heights of the parent- rees sprouting sucker, in relation to sites, were : 5.43 m/Chandpura, 4.40 m/Laxmanpura and 4.20 m/Nayakhera, whereas, the same in relation to topography were : 5.83 m/base, 4.77 m/top and 3.50 m/slope. Site-wise, the minimum and the maximum measurements recorded for the parent-tree height were: 3.00 m and 11.0 m respectively in Chandpura : 3.00 m and 8.50 m respectively in Laxmanpura and 2.5 m and 7.0 m respectively in Nayakhera. The same in relation to topography were : 3.50 m/both, Laxmanpura & Nayakhera and 9.00 m/Chandpura respectively on top; 2.50 m/Nayakhera and 4.00 m/all the three sites respectively on slope and 3.00 m/Nayakhera and 11.00 m/ Chandpura respectively on base. The cumulative average height of parent-trees sprouting sucker, as analysed, was 4.85 m.

The collective average regarding height of the generated suckers, as calculated, was 2.03 m. However, the site-wise averages were : 2.24 m/Chandpura, 2.00 m/Laxmanpura and 1.63 m/Nayakhera and the same in relation to topography were : 2.23 m, 1.92 m and 1.86 m on base, top and slope respectively. The minimum and the maximum height of the sucker-generated culm in each of the three forests was :

PLATE - 24. A ROOT SUCKER PRODUCED BY ANOGEISSUS PENDULA TREE ON ONE OF THE PLATEAUS IN LAXMANPURA FOREST BLOCK. THE COLLAR - GIRTH OF THE SPROUTED SUCKER WAS THE MAXIMUM WITH RESPECT TO TOPOGRAPHY.

PLATE - 25. THE TINIEST SUCKER SPROUTED ON ONE OF THE HORIZONTALLY SPREADING PARENT ROOTS OF A. PENDULA (INDICATED BY A BLACK ARROW ON THE RIGHT HAND SIDE). THE PARENT TREE WAS FOUND GROWING ON A SLIGHTLY INCLINED SURFACE IN CHANDPURA FOREST BLOCK.





0.15 m/slope (Plate No - 25) and 6.5 m/base respectively in Chandpura; 1.00 m and 3.5 m respectively, both on the base in Laxmanpura and 0.50 m and 3.00 m respectively, both on the top in Nayakhera blocks. The same in relation to topography was : 0.50 m/Nayakhera and 3.00/all the three sites respecively on top; 0.15 m/Chandpura and 2.50 m/both, Chandpura & Nayakhera respectively on slope and 1.00 m/all the three sites and 6.50 m/Chandpura respectively on base.

Regarding soil-depth at which the parent-root produced sucker, the average values in relation to sites were : 16.5 cm, 9.1 cm and 7.3 cm in Chandpura, Laxmanpura and the Nayakhera blocks respectively. The same in relation to topography were : 17.0 cm, 10.5 cm and 9.25 cm on base, top and slope respectively. The collective average value, including all the three sites, as calculated, was : 11.9 cm. The minimum and the maximum soil-depths, at which the sucker generated from the parent-root, in relation to topography, were : 5.0 cm/both, Laxmanpura & the Nayakhera and 26.0 cm/ Chandpura respectively on top; 4.0 cm/Laxmanpura and 20.0 cm/Chandpura respectively on slope and 5.0 cm/Nayakhera and 80.0 cm/Chandpura (Plate - 26) respectively on base. The same values in relation to sites were : 5.0 cm/slope and 80.0 cm/base respectively in Chandpura; 4.0 cm/slope and 23.0 cm/top respectively in Laxmanpura and 5.0 cm/on all i.e., top, slope and the base each and 15.0 cm/base respectively in Nayakhera forests.

TABLE - 7.2 OVERALL AVERAGES, MAXIMUM - MINIMUM VALUES, AND THE COLLECTIVE AVERAGE OF DIFFERENT PARAMETERS OF PARENT TREES, SUCKERS AND THE SUCKER - GENERATED CULMS OF ANOGEISSUS PENDULA IN RELATION TO VARIOUS SITES AND TOPOGRAPHY.

SITES & TOPOGRAPHY		MORPHOLOGICAL PARAMETERS								
		M-I	M-II	M-III	M-IV	M-V	M-VI	M-VII	M-VIII	M-IX
SITES :										
CHANDPURA :	Av.	0.482	5.42	0.165	0.165	0.326	0.172	2.24	12.5	4.50
	S.E.	± 0.052	± 0.541	± 0.014	± 0.036	± 0.083	± 0.030	± 0.287	± 0.697	± 0.51
	Max.	0.98	11.00	0.31	0.80	1.77	0.62	6.50	17.0	8.0
	Min.	0.26	3.00	0.08	0.05	0.10	0.08	0.15	7.0	1.0
LAXMANPURA:	Av.	0.367	4.40	0.146	0.091	0.197	0.117	2.00	12.6	3.13
	S.E.	± 0.038	± 0.379	± 0.013	± 0.013	± 0.022	± 0.015	± 0.183	± 1.004	± 0.44
	Max.	0.76	8.50	0.26	0.23	0.35	0.26	3.50	19.0	6.0
	Min.	0.26	3.00	0.08	0.04	0.09	0.07	1.00	7.0	1.0
NAYAKHERA :	Av.	0.375	4.20	0.146	0.073	0.157	0.112	1.63	12.2	2.90
	S.E.	± 0.033	± 0.334	± 0.013	± 0.008	± 0.017	± 0.009	± 0.165	± 0.868	± 0.41
	Max.	0.62	7.00	0.24	0.15	0.31	0.21	3.00	18.0	6.0
	Min.	0.26	2.50	0.08	0.05	0.05	0.07	0.50	8.0	1.0
TOPOGRAPHY :										
TOP :	Av.	0.402	4.77	0.140	0.094	0.218	0.114	1.92	11.4	3.40
	S.E.	± 0.027	± 0.355	± 0.011	± 0.014	± 0.037	± 0.012	± 0.218	± 0.505	± 0.35
	Max.	0.71	9.00	0.24	0.23	0.68	0.26	3.00	15.0	6.0
	Min.	0.31	3.50	0.08	0.05	0.09	0.08	0.50	9.0	1.0

(Continue)

(Continued)

SLOPE	: Av.	0.297	3.50	0.131	0.102	0.191	0.115	1.86	15.5	5.05
	S.E.	± 0.011	± 0.103	± 0.007	± 0.011	± 0.019	± 0.016	± 0.120	± 0.564	± 0.28
	Max.	0.40	4.00	0.26	0.20	0.41	0.41	2.50	19.0	8.0
	Min.	0.26	2.50	0.08	0.05	0.08	0.08	0.15	9.0	2.0
BASE	: Av.	0.537	5.83	0.197	0.152	0.315	0.191	2.23	8.9	1.80
	S.E.	± 0.061	± 0.628	± 0.018	± 0.049	± 0.109	± 0.035	± 0.381	± 0.500	± 0.16
	Max.	0.98	11.00	0.31	0.80	1.77	0.62	6.50	13.0	3.0
	Min.	0.26	3.00	0.08	0.04	0.05	0.08	1.00	7.0	1.0
COLLECTIVE AVERAGE :		0.426	4.85	0.155	0.123	0.251	0.143	2.03	12.5	3.80

LEGENDS : M-I = Girth (gbh) of the parent-tree sprouting sucker (m), M-II = Approximate height of the parent tree (m), M-III = Circumference (m) of the parent-root sprouting sucker, M-IV = Soil depth (m) at which the sucker sprouts from the root, M-V = Distance of the sucker (m) from trunk base of the parent-tree, M-VI = Collar-girth (m) of the root sucker, M-VII = Height of the sucker-generated culm, M-VIII = Numbers of secondary roots present in the sucker, M-IX = Total number of suckers present in a parent-tree.

Av. = Average, S.E. = Standard error, Max. = Maximum, Min. = Minimum

As regards the distance of the sprouted sucker from the trunk-base of its parent-tree, the cumulative average as calculated was 25.1 cm. Average values of distance in relation to sites were : 32.6 cm, 19.7 cm and 15.7 cm in Chandpura, Laxmanpura and the Nayakhera blocks respectively. The same in relation to topography were : 31.5 cm, 21.8 cm and 19.1 cm on base, top and slope respectively. The minimum and the maximum distance of the sucker from the trunk-base of its parent-root, in relation to topography were : 9.0 cm/ Laxmanpura and 63.0 cm/Chandpura respectively on top; 8.0 cm/ Nayakhera and 41.0 cm/Chandpura respectively on slope and 5.0 cm/Nayakhera (Plate - 27) and 177 cm/Chandpura (Plate - 26) respectively on base. The same values in relation to sites were : 10.0 cm/base and 177.0 cm/base respectively in Chandpura; 9.0 cm/top and 35.0 cm/slope respectively in Laxmanpura and 5.0 cm/base and 31.0 cm/top respectively in Nayakhera blocks.

Lastly, the number of secondary roots present in the sucker were also recorded. Average number of secondary-roots per sucker in relation to sites were : 12.6, 12.5 and 12.2 in Laxmanpura, Chandpura and the Nyakhera blocks respectively. The same in relation to topography were : 15.5, 11.4 and 8.9 on slope, top and the base respectively. The minimum and the maximum number of secondary-roots per sucker in relation to

PLATE - 26. THE DEEPEST AND THE DISTANTLY SPROUTED ROOT SUCKER OF ANOGEISSUS PENDULA, EXCAVATED ON A BASE OF CHANDPURA FOREST BLOCK. IT IS DIFFICULT TO DISTINGUISH THE PARENT TREE AND THE SUCKER GENERATED TREE.

PLATE - 27. THE NEAREST SUCKER OF ANOGEISSUS PENDULA, NOTICED ON A BASE OF NAYAKHERA FOREST BLOCK.





sites were : 7/base and 17/slope respectively in Chandpura; 7/base and 19/slope respectively in Laxmanpura and 8/slope and 18/slope respectively in the Nayakhera forests. The same in relation to topography were : 9/Nayakhera and 15/ Chandpura respectively on top; 9/Chandpura and 19/Laxmanpura respectively on base and 7/both, Chandpura & the Laxmanpura and 13/both, Chandpura & Nayakhera respectively on slope. Interestingly enough, the site-wise average values of the number of secondary-roots per sucker nearly corresponds with the collective average, which as calculated was 12.5 .

7.5 R O O T - G R A F T S

DURING all these extensive studies of the natural regeneration through root-suckers in Anogeissus pendula trees, a very interesting phenomenon of coalition of roots was observed. This coalition was noticed to occur profusely where the roots of 'Kardhai' were densely populated in the soil.

Previously, this joining together of the roots was observed only in between the root branches of the same parent tree[366], but later on the coalition of roots in between two different individuals of the same species was also noticed. These associations in between two different individuals were, in case, the 'ROOT-GRAFTS', and they quite

commonly occured in between two or more individual trees of A.pendula. In a typical white pine forest, over fifty percent of the trees may be so linked together[63]. An interesting result, of this tendency to form extensive root-grafts, is that a large group of trees may become so closely associated that, in fact, they form one individual.

7.6 I N T E R P R E T A T I O N S

IT seems that the natural regeneration of Anogeissus pendula through seeds was not very successful, because of the conditions extremely unfitting for the establishment of its seedlings due to either a high percentage of mortality[453] or the utmost distressed biotic interferences. However, the regeneration of A.pendula through root-suckers was found in plenty in the natural conditions. This observation was in accordance-with the findings of Troup. Other structural details, not covered by Troup or any other worker, are discussed here.

It was interesting to observe that the sucker-generated plants of 'Kardhai' were generally in form of culms and were abundant in the open forest i.e., where the tree-canopy was sparse and open.

Gala ya sana dig that, there is direct relation between girth and the age of a tree. Girth increases with

the increase in age. In the present study, girth of the parent-tree sprouting sucker was found to be maximum on base and minimum on slope in all the three sites. On the basis of these observations and in view of the ut supra facts, it can be interpreted that on slopes A.pendula trees were much more capable of sprouting a sucker, very early in their life, whereas on the base, it were generally the more matured trees, able to do so. The physiology behind this is not understood.

Similarly, the values of height of the parent-trees seems to be of use in deducing the relation between parent tree and the produced sucker. Gemrally, the sucker generating trees on slopes were relatively of lesser heights, whereas, on base they were of greater heights. Surprisingly, the maximum values of parent-tree height, both, on an average basis and on the individual basis, were recorded on the base; whereas, the minimum values on both the basis were observed on the slopes. Now, if the height has any relation (certainly direct) with the age of the tree, it can be again inferred that on slopes the Anogeissus pendula trees seems to be much more capable of sprouting sucker in the juvenile phase of their life, whereas, on base they do so but in the later phase of their life.

The story of sucker, as related to its own height

seems not to be encouraging. On an average basis, plant or the culm produced through the sucker (i.e., sucker-generated culm) was generally poor in growth and height. However, this was not always the case. Some of the sucker-generated plants were quite large and strong. Thus, it is assumed that the sucker-generated plant may grow equivalent to the height of the seed-germinated parent-tree, if the conditions for its growth becomes suitable depending on various environmental factors.

Observations and calculations made on girth or circumference of parent-roots producing sucker were quite variable. Hence, no interpretation could be made. However, it can be inferred that any of the secondary root of the parent-tree may produce sucker. Or in other words, the parent-root capable of sprouting into a sucker could be of either small or large size. Similarly, there seems to be no relation between collar-girth of the sucker and sites or topography.

Results of the measurements of soil depth, at which the parent-root produced sucker, narrates slightly different story. It seems that on top and nearly on slopes as well, the suckers generally sprout from the horizontal root-system of the parent-tree, whereas, on base it was the more deeper roots preferably the vertical root-system which

sprouted into a sucker. It is also assumed that since on slopes the root-system are generally more exposed due to steepness, the depth of the soil at which the sucker sprouts is relatively less. Hence, in view of the above inferences, it can be asserted that any of the system of parent-root i.e., horizontal or vertical, may sprout into a sucker depending upon the circumstances prevailing at the time of sprouting.

Root-system of seed germinated trees was found to be more compact and symmetrical than that of the sucker generated tree. This might be because of the well developed vertical and the horizontal system in seed germinated trees. The vertical system penetrated much deeply in soil, whereas, the horizontal system developed a compact and intervened net-work of roots for providing mechanical support to the plant. On the other hand, the root-system of sucker generated plant was characterized by much developed horizontal-system than its vertical-system.

Ad finem, there seems some relation between the number of secondary roots present in a sucker and the topography. The table itself speaks that the maximum number of secondary roots, on an average basis, were present in the sucker sprouted on slope, whereas, the minimum were recorded in the sucker sprouted on base.

Thus, it seems that the present study has developed a lustrous picturesque of a feebly controversial sucker of *Anoteiseus pendula*.

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CHAPTER - VIII

SILVICULTURAL TREATMENTS

CHAPTER - VIII

SILVICULTURAL TREATMENTS

8.1 PREMISE

MANKIND has derived varied inspirations from the Nature since times immemorial. The forests and its yields have been the source of prosperity and happiness to millions of people for thousands of years. It is in the forest resources that a great potential for economic development of the state exists. Forests are rightly considered to be the 'GREEN-GOLD' for the states. Government efforts in the scientific treatment of forests have been invariably inadequate and inappropriate to cope with the accelerating rate of utilization, resulting in the increasing hectarage of unproductive forests and the rising incidence of damaged water-sheds, ravaged wild-life and the abused grazing lands.

In sooth, the silviculture is a scientific-art, that adroitly embellish the deformed forest and its component species. Silviculture is the backbone of forestry. It deals with the forest as a biotic complex - its types; factors influencing it; its composition; regeneration etc.

With the increasing demand on tree improvement and for optimising biomass production, the importance of

vegetative propagation has increased. Much emphasis is being laid now on the artificial regeneration of tree species for social and agro-forestry programmes. Regeneration is the act of replacing old trees or renewal of a forest either naturally or artificially by vegetative propagation[421]. A multiplication by vegetative means offers the advantage of greater genetic uniformity and immediate availability of superior clones for plantation[16].

The term 'SILVICULATURE' has been defined variously. Some of the interesting definitions can be reproduced, ut infra:-

* " The term 'silviculture' in English commonly refers to only certain aspects of the theory and practice of raising forest crops."
  - H.G.CHAMPION and S.K. SETH[77].

* " Silviculture is the art and science of cultivating forest crops."
  - INDIAN FOREST & FOREST PRODUCT TERMINOLOGY.

* " Silviculture is that branch of forestry which deals with the establishment, development, care and reproduction of stands of timber."
  - J.W.TOUMEY and C.F.KORSTIAN[446].

Silviculture is usually desirable and often a necessity[75, 76], but it should be emphasized that its practices to be most effective, should be governed by ecological knowledge[291].

8.2 REVIEW OF LITERATURE

The conventional methods of vegetative propagation are by rooting of vegetative parts. Rooting of stem cuttings is one of the important means of vegetative propagation which is generally practiced in forestry and horticulture to obtain plants of desired genetic constitution within a short spell of time. The potential for increased genetic gain through vegetative propagation of forest tree has been demonstrated by a great number of silviculturists[52, 67, 202, 212, 266, 269, 278, 382, 505].

Cela vs sans dit that the growth regulators play a significant role in controlling the rooting ability of stem segments[14, 58, 148, 204, 267, 293, 335, 417, 445]. Auxins have been found to stimulate rooting in stem cuttings of several plants[58, 270, 293]. Both Punica granatum and Dalbergia sissoo are hard to root. species. But exogenous application of auxins not only enhanced root formation, it increased the number of roots per cutting and average root length as well[382]. In Dalbergia latifolia the auxins increased both, the number of rooted cuttings and rooting percentage[278]. Raising of Nerium plant through cuttings is a common garden-practice, but application of IAA may enhance the

capacity of regeneration of stem cuttings[293]. Exogenous application of auxins resulted in the root formation in a considerable number of cuttings in Dalbergia sissoo even during the failure months of winter[335]. However, Acacia albida was successfully raised from the shoot cuttings without applying any root inducing hormone. The sprouted cuttings not only developed a healthy horisontal root-system but also exhibited vigour and a continuous growth after their plantation[15, 82, 153].

The variation in rooting capability is variously explained. Trees show juvenility gradients with epicormics, root-suckers, stump-sprouts and severely pruded trees producing juvenile shoots[61]. A high degree of success was obtained in vegetative propagation of Casuarina equisetifolia with cladode cuttings taken from a 15 months old plant[146]. Experiments with Eucalyptus spp., had shown that branches and the leafy cuttings taken from mature trees show 'obstinancy' to rooting, but the juvenile tissues such as coppice-sprouts root with ease and high degree of success[147]. The cuttings obtained from terminal shoots of Populus ciliata rooted better than the mature w wood-cuttings[189]. Among the physiological differences between the juvenile and mature wood cuttings, the former always root easily[479].

8.3 MATERIAL AND METHOD

One of the problems confronting wide scale

artificial regeneration of Anogeissus pendula, however, is the lack of proper silvicultural information concerning propagation of the species. Hence, for developing reliable techniques of vegetative propagation, following three silvicultural experiments were performed in October, 1986 :

(a). Branch cuttings,
(b). Root cuttings, and
(c). Sucker plantations.

8.3(a) B R A N C H C U T T I N G S

Juvenile and uniform sized branch cuttings of 25 cm length and 2.5 cm girth were culled from the fresh shoots (one year old branches) of ten different individuals of A.pendula tree growing in Bangawa and Laxmanpura forests each. The gbh of these individuals ranged in between 30 cm and 75 cm.

After excising the apical part and the leaves, the composit sample of the cuttings was divided into 21 groups with 50 cuttings in each. Aqueous solutions of Indole butyric acid (IBA), Gibberellic acid (GA), Kinetin (KN), Maleic hydrazide (MH) and Coumarin (COU) each at four different concentrations viz., 10, 50, 100 and 500 ppm were prepared a fresh. For treatments, about 8 cm basal cut-ends

PLATE - 28. HORMONALLY TREATED BRANCH CUTTINGS OF ANOGEISSUS PENDULA, PLANTED ON A RAISED NURSERY BED IN GOVT. FOREST NURSERY, BANGAWA.

PLATE - 29. SOME OF THE PLANTED BRANCH CUTTINGS OF ANOGEISSUS PENDULA, EXHIBITING SPROUTING OF LEAVES. (PHOTOGRAPHED ON THE 28th DAY OF PLANTATION).

MONALLY TREATED BRANCH CUTTINGS
NDULA. PLANTED ON A RAISED
GOVT. FOREST NURSERY, BANGANA.

E OF THE PLANTED BRANCH
RIGGUS PENDULA, EXHIBITING
VES. (PHOTOGRAPHED ON THE
MEATION).





of the cuttings were dipped in the respective hormonal test solutions for a continuous period of 24 hours in dark. Last group of 50 cuttings was treated for the same duration simply with plain distilled water to serve as control. Treated cuttings were then immediately transferred to raised nursery beds. These test cuttings were planted very slightly oblique (Plate - 28).

Observations on sprouting of leaves were made and recorded after 7, 14, 28, (Plate - 29), 42 and 60 days of their plantation , whereas, observations on rooting potential of the cuttings were after 60,90, 120, 150 and 180 days (Plate - 30) of their plantation. Each time 10 cuttings under each category of the treatments were randomly drawn-off the nursery bed with all care.

8.3(b) R O O T C U T T I N G S

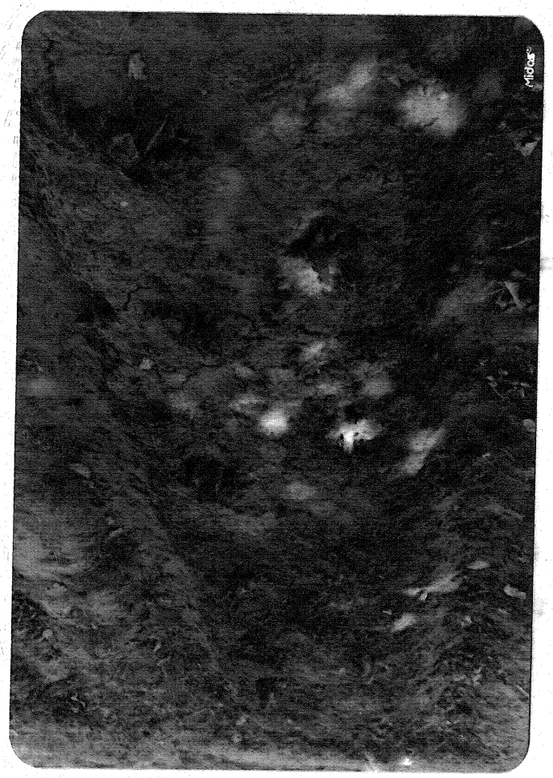
20 cm long root-cuttings with uniform girth of 2.0 cm were collected from the roots of A.pendula trees growing in Bangawa and Laxmanpura forests. Secondary roots and other root laterals were excised and the composit sample of the cuttings was planted in raised nursery beds by adopting three positions of planting, at infra :

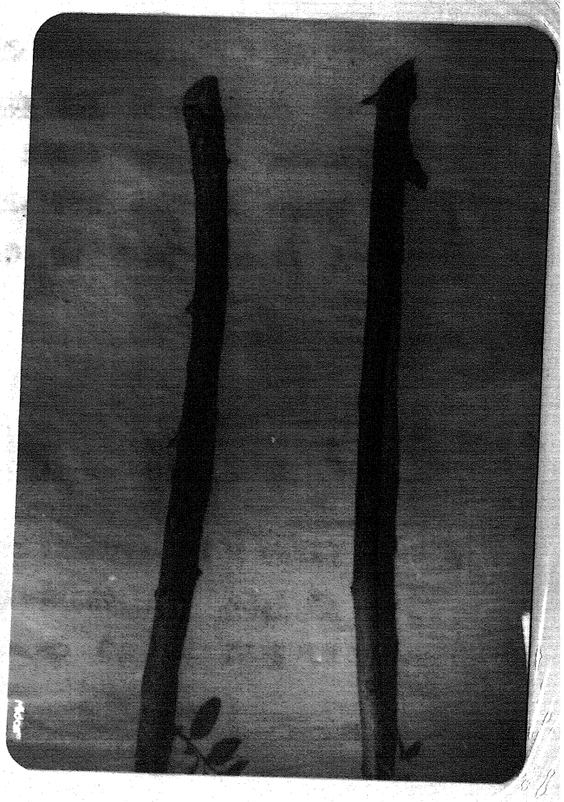
(1). Vertical, with one-third portion of an apical end exposing above.

(2). Both the cut-ends of the cutting inserted in soil and one-third middle portion

PLATE - 30. (LEFT) - TWO OF THE MANY BRANCH CUTTINGS OF *AMORPHOPHALLUS PENDULA* AFTER HARVESTING THEM ON 180th DAY OF THEIR PLANTATION IN ORDER TO RECORD THEIR ROOTING POTENTIALS. IT CAN BE NOTED THAT NOT A SINGLE SIGN OF CALLUS FORMATION WAS PRESENT.

PLATE - 31. (RIGHT) - EXCISED ROOT - SUCKER OF *AMORPHOPHALLUS PENDULA* TRANSPLANTED ON A RAISED NURSERY BED WITH A MINIMUM OF 50 cm SUCKER TO SUCKER DISTANCE.





exposed above.

(3). Horizontal, with none of the portion exposing.

In each of the *ut supra* positional treatment, numerally 50 cuttings of root were utlized. No hormone or any other chemicals was applied on the root-cuttings. Beds were irrigated *per diem* regularly with river water. These planted cuttings were monitered frequently for their sprouting. They were very carefully withdrawn from the beds after 60, 90, 120, 150 and 180 days of planting. Each time 10 cuttings under each of the three positions were randomly picked and were keenly observed for their rooting behaviours.

3.3(c) SUCKER PLANTATIONS

Investigations were undertaken to study the sprouting and rooting response of transplanted root-suckers of *A.pendula*. For this, 10 - 15 cm long root suckers were stripped off from the parent roots of four different girth classes of 'Kardhai' trees. Six suckers were culled from each girth class of parent tree. These suckers, immediately after their collections, were placed in a trough containing water in order to avoid dessication. The leaf and roots present on the sucker were excised. Collar girth and fresh weight of the gathered sucker was determined at the spot before placing it in trough. Girth was measured with the help of a calibrated

tape, whereas, the weight was detected by making use of a portable lever balance.

The amassed suckers under each girth class were divided into two groups on the basis of their recorded initial weights. Suckers having less than 500 g of weight were considered in group-I, whereas, suckers with more than 500 g of their weight were kept under group-II. Thus, following eight categories of suckers were formed:

Group - I : Suckers 500 g weight

(1). Sucker culled from 25 cm gbh of *A.pendula*
(2). " " " 25 - 50 cm " "
(3). " " " 50 - 75 cm " "
(4). " " " 75 cm " "

Group - II : Suckers 500 g weight

(5). Sucker culled from 25 cm gbh of *A.pendula*
(6). " " " 25 - 50 cm " "
(7). " " " 50 - 75 cm " "
(8). " " " 75 cm " "

These categories, hereafter, will be known as SC-1, SC-2, SC-3, SC-4, SC-5, SC-6, SC-7, and SC-8 respectively The suckers were atonce, after their collections, transported to the nursery and were immediately planted in raised nursery beds at 50 cm sucker to sucker distance. (Plate - 31, 32 & 33). None of the sucker was treated with growth hormone or any other

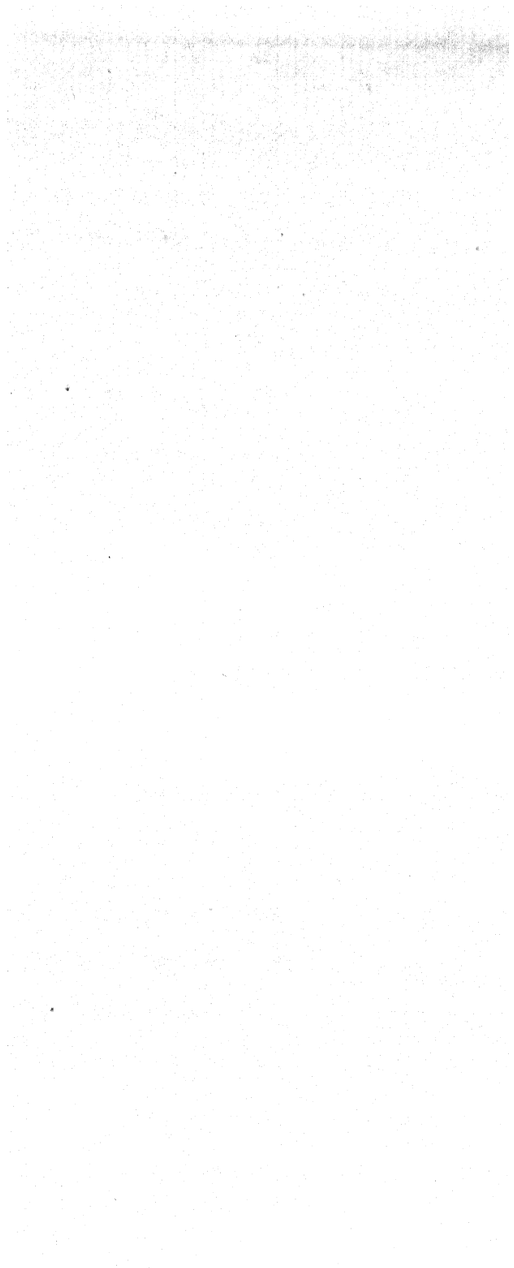


PLATE - 32. ROOT SUCKER OF ANGORISSUS PENDULA IN A RAISED NURSERY BED AFTER 15 DAYS OF ITS TRANSPLANTATION.

PLATE - 33. ONE OF THE PLANTED ROOT SUCKERS OF ANGORISSUS PENDULA EXHIBITING SPROUTING OF BRANCHES AND LEAVES. (PHOTOGRAPHED ON 30th DAY OF ITS TRANSPLANTATION).


Midas


Midas

chemicals. Beds were profusely irrigated per diem with river water.

The planted suckers were carefully uprooted after 150 days and were subjected to measurements of various growth aspects, field performance and dry matter productions. After excising all the measured sprouted parts of shoot and root, each sucker was finally weighed by making use of the same lever balance. The excised parts were kept in oven at 70°C till constant weight for determining their biomass.

8.4 O B S E R V A T I O N S

THE sprouting behaviour of leaves in the branch cuttings was very good under each of the treatments including control. Sprouting gradually increased from 1st week to 6th week of plantation. Thereafter, the sprouted leaves abruptly abscissed and on 60th day of observation, none of the cuttings were seen containing any fresh leaf.

The average number of sproutings in each of the treatments on 42nd day were invariably nearly equal to the average number of sproutings in the control. Out of a total 1,050 cuttings, sprouting of leaves took place in 913. Thus, nearly 87 percent of the cuttings were able to sprout. In control itself, sprouting performance of the cuttings was 83%.

However, observations on rooting potential of

TABLE - 8.1 MEASUREMENTS OF ANOGEISSUS PENDULA ROOT SUCKERS* BEFORE AND 150 DAYS AFTER THEIR PLANTATIONS.

PARAMETERS	R O O T S U C K E R C A T E G O R I E S							
	SC - 1	SC - 2	SC - 3	SC - 4	SC - 5	SC - 6	SC - 7	SC - 8
COLLAR GIRTH (cm) :								
Av.	11.67	12.00	14.67	16.33	25.33	16.00	16.33	18.67
S.E.	± 1.764	± 1.028	± 2.184	± 2.081	± 5.917	± 2.838	± 1.968	± 2.026
INITIAL FRESH WEIGHT (g) :								
Av.	269.67	191.50	279.00	262.67	1006.00	841.33	1076.50	864.50
S.E.	± 24.229	± 13.563	± 21.826	± 23.534	± 97.185	± 72.837	± 103.361	± 69.497
FINAL FRESH WEIGHT (g) :								
Av.	235.17	158.67	249.50	224.50	934.50	770.17	911.83	801.00
S.E.	± 19.361	± 19.815	± 17.437	± 20.365	± 84.372	± 76.521	± 87.958	± 73.234
PERCENTAGE OF LOSS IN WEIGHT :								
Av.	12.79	17.14	10.57	14.53	7.11	8.46	15.30	7.35
S.E.	± 2.699	± 2.152	± 1.963	± 2.109	± 0.988	± 1.114	± 2.683	± 1.266

* 5 Replicates

LEGENDS : Root Sucker category = Please see the text.

Av. = Average , S.E. = Standard error, g = grams

the branch cuttings were not positive. None of the cuttings were able to root in any of the observations made on 60, 90, 120, 150 and 180th day of plantation. Hence, the experiment failed to propagate the species through branch cuttings.

Similarly, in experiment no. 8.3(b) regarding root cuttings, all the results were negative. The cuttings neither sprouted not rooted upto 180th day of plantation. Alas, the fate of this experiment was also the same.

Surprisingly, the planted suckers of 'Aardhai' produced cent-percent positive results. Sprouting of branches, leaves and rooting took place in all the 24 suckers divided into 8 categories of 3 each. It can be noticed form Table 8.1 that the planted suckers finally lost their weights. Collectively the loss in weight was 11.66 percent. On an average, maximum loss of 17.14% in weight occured in the suckers of category SC-2, whereas, minimum 7.11% of loss in weight took place in the suckers of category SC-5.

Table 8.2(a) gives an idea of an average number of shoots and the secondary roots produced by a sucker under each category after 150 days of plantations. Column of shoots display that on an average, not less than 5.7 shoots per sucker sprouted (SC-5) with upper average limit of 8.3 shoots per sucker (SC-6). Results of the number of secondary roots

TABLE - 8.2.(a) NUMBER OF SHOOTS AND SECONDARY ROOTS SPROUTED IN THE ROOT SUCKERS* OF ANOGEISSUS PENDULA (150 DAYS AFTER THEIR PLANTATIONS).

SUCKER CATEGORY		NUMBER OF SHOOTS	NUMBER OF SECONDARY ROOTS
SC - 1	AV.	7.7	9.7
	S.E.	± 1.026	± 1.084
SC - 2	AV.	6.3	11.3
	S.E.	± 1.328	± 2.216
SC - 3	AV.	8.0	17.3
	S.E.	± 1.794	± 2.742
SC - 4	AV.	6.7	14.3
	S.E.	± 1.666	± 1.980
SC - 5	AV.	5.7	13.7
	S.E.	± 1.982	± 1.462
SC - 6	AV.	8.3	10.7
	S.E.	± 2.012	± 1.822
SC - 7	AV.	7.3	8.3
	S.E.	± 1.774	± 0.796
SC - 8	AV.	6.7	16.7
	S.E.	± 1.286	± 1.874

* Average of 3 suckers

LEGENDS : Sucker category = Please refer to the text of Chapter VIII Section 8.3.(c).

AV. = Average, S.E. = Standard error

TABLE - 8.2.(b) AVERAGE GROWTH PERFORMANCE OF THE PLANTED ROOT SUCKERS* OF ANOGEISSUS PENDULA (150 DAYS AFTER THEIR PLANTATION).

SUCKER CATEGORY		PHOTOSYNTHETIC AREA (cm sq.)	SHOOT LENGTH (cm)	TOTAL ROOT LENGTH (cm)**	SHOOT/ROOT LENGTH RATIO
SC - 1 :	Av.	189.66	33.37	34.17	0.9766
	S.E.	± 17.654	± 2.916	± 3.176	± 0.0296
SC - 2 :	Av.	159.36	27.63	33.37	0.8280
	S.E.	± 13.624	± 2.584	± 3.292	± 0.0316
SC - 3 :	Av.	197.78	33.57	53.13	0.6318
	S.E.	± 21.126	± 3.184	± 4.904	± 0.0224
SC - 4 :	Av.	178.46	31.47	58.00	0.5426
	S.E.	± 19.434	± 1.996	± 5.128	± 0.0278
SC - 5 :	Av.	163.82	29.33	32.63	0.8989
	S.E.	± 17.638	± 2.378	± 3.022	± 0.0398
SC - 6 :	Av.	211.66	35.63	36.90	0.9656
	S.E.	± 24.584	± 2.966	± 2.760	± 0.0376
SC - 7 :	Av.	181.58	32.53	30.83	1.0051
	S.E.	± 17.616	± 2.184	± 2.562	± 0.0544
SC - 8 :	Av.	168.66	30.27	49.17	0.6156
	S.E.	± 18.750	± 1.896	± 4.226	± 0.0382

* 3 Replicates

** Total secondary roots

LEGEND : Sucker category = Please see the text

Av. = Average, S.E. = Standard error

produced by the planted sucker was encouraging. Average number of secondary roots ranged from minimum 8.3 (SC-7) to maximum 17.3 (SC-3).

Table 8.2(b) provides data on average growth performance of planted sucker after 150 days of plantation. Total average photosynthetic area varied from minimum 159.36 sq. mm (SC-2) to maximum 211.66 sq. mm (SC-6). Average length of shoots produced by the sucker ranged from maximum 35.63 cm (SC-6) to minimum 27.63 cm (SC-2). In this parameter, the length only of the leading shoot produced on each sucker was recorded. Regarding root length, since none of the suckers produced other than the secondary roots, it was rather impossible to record length of any main root produced. Hence, a total length of the secondary roots sprouted per sucker was considered as a total root length. And the same data was used for calculating shoot/root length ratio. Average length of secondary roots fluctuated from minimum 30.83 cm (SC-7) to maximum 58.00 cm (SC-4). Shoot/root length ratio drooped from 1.0551 to 0.5426 in the following descending sequence : 1.0551 (SC-7) > 0.9766 (SC-1) > 0.9656 (SC-6) > 0.8989 (SC-5) > 0.8280 (SC-2) > 0.6318 (SC-3) > 0.6156(SC-8) > 0.5426 (SC-4).

Table 8.2(c) informs regarding data collected on average dry matter production and percent moisture contents in

TABLE - 8.2.(c) AVERAGE DRY MATTER PRODUCTION AND PERCENTAGE MOISTURE CONTENTS IN THE PLANTED ROOT SUCKERS* OF ANOGEISSUS PENDULA (150 DAYS AFTER THEIR PLANTATIONS).

SUCKER CATEGORY		LEAVES		SHOOT**		ROOT		SHOOT/ROOT DRY WEIGHT RATIO
		A	B	A	B	A	B	
SC - 1 :	Av.	1.2614	81.06	2.1636	66.16	1.5792	51.88	1.3700
	S.E.	± 0.4018	± 3.44	± 0.4426	± 2.46	± 0.2302	± 2.76	± 0.1254
SC - 2 :	Av.	1.0328	78.48	1.7018	67.38	1.2704	50.76	1.3396
	S.E.	± 0.4166	± 2.78	± 0.3942	± 3.78	± 0.3496	± 3.98	± 0.1434
SC - 3 :	Av.	1.3158	80.97	2.2098	63.84	1.5324	52.80	1.4421
	S.E.	± 0.4854	± 4.46	± 0.3648	± 3.16	± 0.3104	± 4.14	± 0.1836
SC - 4 :	Av.	1.1778	77.92	1.9646	64.46	1.3494	51.16	1.4559
	S.E.	± 0.6492	± 3.98	± 0.4714	± 2.98	± 0.2946	± 3.76	± 0.1456
SC - 5 :	Av.	1.0732	81.64	1.7826	66.88	1.1938	48.24	1.4932
	S.E.	± 0.2704	± 4.14	± 0.3824	± 2.68	± 0.3622	± 3.34	± 0.1850
SC - 6 :	Av.	1.4168	80.24	2.4668	63.94	1.6046	49.98	1.5373
	S.E.	± 0.3932	± 3.74	± 0.4226	± 2.74	± 0.4116	± 4.74	± 0.1578
SC - 7 :	Av.	1.1884	79.46	1.9946	65.96	1.3532	51.74	1.4740
	S.E.	± 0.5624	± 2.36	± 0.3124	± 4.18	± 0.2836	± 4.22	± 0.1044
SC - 8 :	Av.	1.1032	78.28	1.8584	62.98	1.2772	52.86	1.4551
	S.E.	± 0.4304	± 3.82	± 0.3048	± 2.86	± 0.2144	± 4.86	± 0.1186

* 3 Replicates

** Including values of leaves

LEGENDS : A = dry weight (g), B = Percentage moisture
Sucker category = Please see the text
Av. = Average , S.E. = Standard error

root suckers of A.pendula after 150 days of their plantation. Biomass of leaves ranged from minimum 1.0328 g (30-2) to maximum 1.4168 g (30-6) and accordingly the dry matter contents of shoots inclined from maximum 2.4668 g (30-6) to minimum 1.7018 g (30-2). Maximum average dry weight of root as recorded was 1.6046 g (30-6) and minimum 1.1938 g (30-5). shoot/root dry matter ratio oscillated to maximum 1.5373 (30-6) from minimum 1.3396 (30-2).

Generally, the percentage of moisture contents were abundant in leaves followed by in shoots and then in roots. In leaves moisture percentage varied from minimum 77.92% (30-4) to maximum 81.64% (30-5), whereas, in shoots it ranged from minimum 62.98% (30-8) to maximum 67.38%(30-2). In roots, the moisture contents fluctuated from minimum 48.24% (30-5) to maximum 52.86% (30-8).

8.5 INTERPRETATIONS

RESULTS of sprouting and rooting trials in branch cuttings and the root cuttings clearly demonstrate that A.pendula is obstinate and did not root even with auxin or other hormonal applications. An interesting point that emerge from these investigations is that sprouting of leaves occurred rather easily and nearly in 87% stem cuttings. This indicates that branch cuttings releived their apical dominance, therefore,

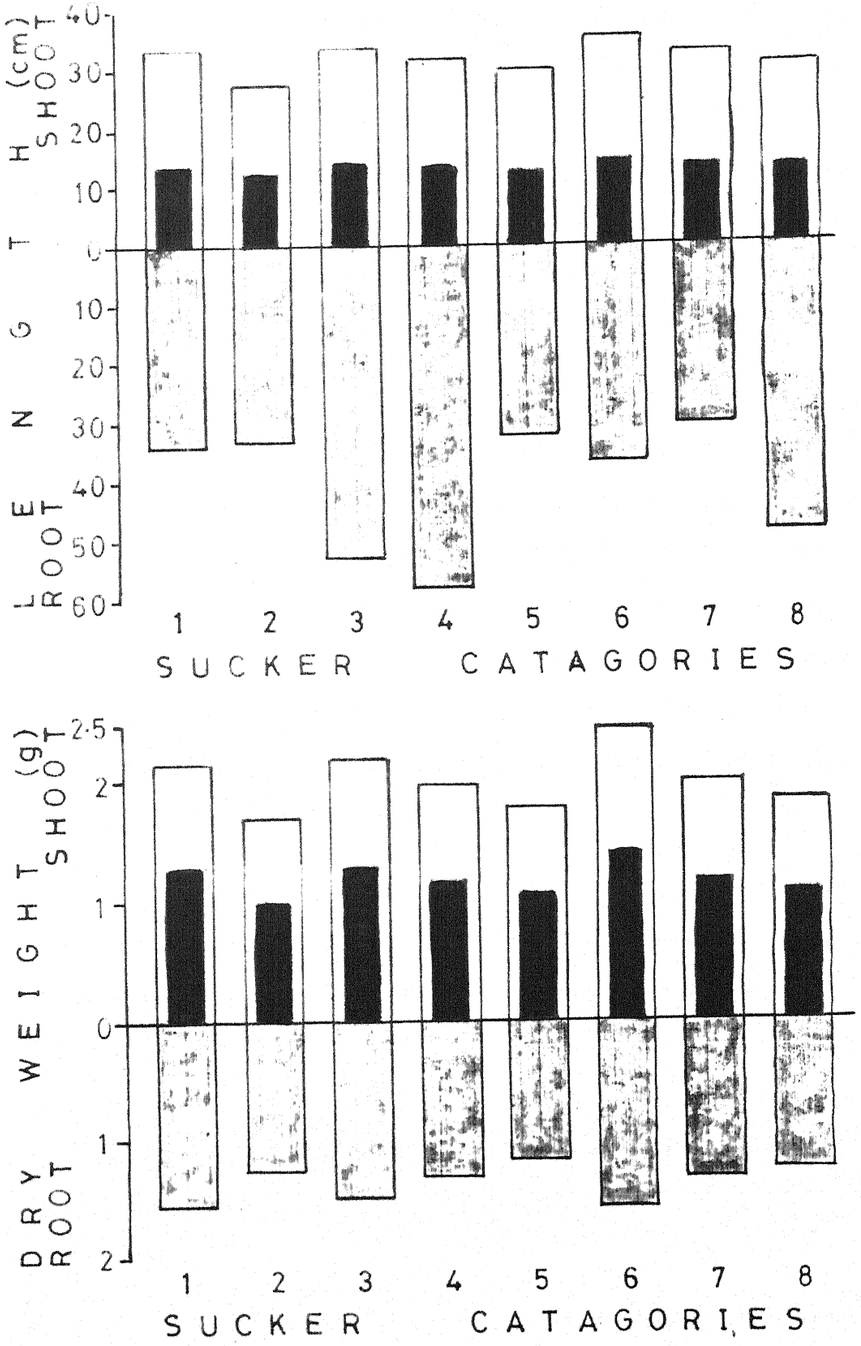


FIG. 8.1 THE AVERAGE GROWTH INCREMENT AND THE DRY MATTER PRODUCTION IN PLANTED ROOT SUCKERS OF A. PENDULA.

several of the branches sprouted from the cuttings. However, they remained alive only for 6 to 7 weeks after which they dried up and even abscissed unexpectedly. It is taken for granted that the reserve food material might have exhausted in 6 weeks of time, may be due to a gradual decrease in the rate of supply through the vascular elements.

Sprouted leaves were photosynthetic and they, *in case* took part in fixing the atmospheric carbon-di-oxide into energy rich carbohydrate. The process would have continued, in case other raw materials, the most important of which was water, could be available. This infact failed, might be due to lack of supply. It is argued that the cuttings were unable to absorb water and minerals *etc.*, in the absence of root.

The cuttings failed not only in exhibiting to root but in displaying callus-formation as well (Plate - 30), even with hormone applications. Similar results were reported in stem cuttings of nearly all the members belonging to the families Berberidaceae, Bignoniaceae, Ebenaceae, Ericaceae, Euphorbiaceae, Juglandaceae, Magnoliaceae, Myricaceae and Proteaceae *etc.*, which did not root even with auxin applications[266].

It is now known that rooting potential of a species is determined by one or more physiological factors,

[164], the more important of which are tissue characteristics, [47], nutrition[119], and hormones[208].

Anatomical studies reveal that easy to root species possess multiseriate vascular-rays opening directly in the cortical region. Rooting initials in these species originate from this region. On the other hand, in difficult to root species there exists a continuous ring of sclerenchyma surrounding the vascular tissue. This ring may serve as a barrier to the penetration of water and to the emergence of root initials[268]. The formation of a sheath of lignified tissue causing a mechanical barrier is probably not the whole or even major cause of failure of rooting, as many plants do not form root initials readily within such a sheath[47]. Secondly, it has also been shown that in Acacia catechu, rooting did not take place in spite of the fact that cambium was active. The failure of cuttings of this species to root could not be ascribed to the sclerification of primary phloem, as no such sheath was observed; but was probably due to nutritional factors as the cuttings were found deficient in starch[270].

In the present investigation it seems that cuttings of A.pendula were probably deficient in reserve food material and due to this nutritional factor they failed to exhibit rooting potential. The results of transplantation

trials of root-suckers (Table 8.2a) compelled to infer the argument ut supra. The table discloses the fact that suckers were able to root with ease. Had there been a sclerenchymatous ring around vascular tissue as argued, the rooting in suckers might have also been checked. But the suckers exhibited success in rooting potentials, therefore, only nutritional factor seems to be responsible for failure in rooting capabilities of baranch and root cuttings of 'Kardhai'.

Juvenile wood often root much more readily than mature wood. This was noted by horticulturists before the concept of juvenility had become generally accepted[126]. Secondly auxins can generally stimulate the rooting of cuttings suggesting that superior rooting of juvenile cuttings may be due to a higher endogenous auxin content[314]. However, presently, neither juvenility nor exogenous application of auxin restored the readiness to root in cuttings of A.pendula . Identical findings with the cuttings of other species difficult to root proposes an explanation based on the decline in content of rooting cofactors[158]:

When auxin or other hormone is the limiting factor its application results in root initiation; at other times absence of other essential factors renders hormones ineffective[43]. The reasons for failure of A.pendula cuttings to root are not

clearly understood. The system involved seems to be complex and require the interpretation of a multiplicity of factors. There is reasons to believe that here factors other than hormones are limiting. These cofactors which are essential may include : Carbohydrate (sucrose), general nitrogen supply, biotin, thiamine, arginine, adenine, guanine, vitamin K and many others not yet known[298].

It has been interpreted that cuttings are generally deprived of their natural auxin source (e.g ., the coleoptile tip) and are also accompanied by a shock reaction entailing among other effects loss of activity of the membrane H^+ ATPase, and the application of hormone merely speeds up the recovery from shock[433]. Hence, in A.pendula cuttings it also seems that shock reaction might be so strong that exogenous application of auxin or other hormones were unable to recover and resume its growth.

Positive results of A.pendula sucker-plantations trial have an extra advantage in that they were tried without applying any root inducing substances and that there was cent percent success. This method of propagating A.pendula vegetatively seems to be most economic and practical. Good potential of rooting in suckers suggest that there might be either no barrier in the cortical region of the sucker or root initials were readily present within them.

Successful establishment of suckers due to their good rooting response suggest another reasonable possibility that the nutritional factor might have the upper hand in the initiation. The results as documented in Table 3.1 provides clue to infer the above argument since there was an overall loss in the initial weight of suckers after their plantation. This loss might have occurred due to the utilisation of stored food materials by the metabolic processes involved in both, sprouting the aerial shoots and most probably in initiating the roots.

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C H A P T E R – IX

E P I T O M E

CHAPTER - IX

E P I T O M E

9.1 P R E M I S E

FORESTRY is a multidisciplinary approach. It is based on the principles and practices derived from various pure and applied fields that are scattered throughout the spectrum of knowledge. Forests are essential for human survival and impose vital impact on climate, soil erosion and floods. Forest is the 'FACTORY' for soil formation and it generate life-gas 'OXYGEN' as its by-product. They are rightly been considered as Earth's 'GREEN LUNGS'.

Many programmes have been launched and much attention is being paid on the afforestation and reforestation of nude areas of low fertility. It is felt that there is an urgent need to select and develope some economically important forest tree species that may survive under arid and semi-arid conditions of that region. One of such tree is Anogeissus pendula Edgew., which is locally known as 'KARDHAI'. It is the most dominated tree luxuriantly growing on the dry eroded

areas of Bundelkhand region. Due to the low viability of the seeds, the artificial regeneration of 'Kardhai' is very often a problem. Natural regeneration of this species in the heavily grazed areas is all the more difficult. Hence it was considered to develope some new and improved skills for increasing the production and establishment of A.pendula and also for raising the best silvicultural technique and germination behaviour.

9.2 STUDY AREA

9.2(a) GEOGRAPHY

Jhansi is geographically situated between 25°10'N - 25°32'N latitude and 78°18'E - 78°45'E longitude and is about 275 m above MSL. Betwa, Pahuj and Jamini are the main rivers flowing within the tract. The banks of these rivers are often flanked by forests. Nearly 6.48 percent of the total geographical area of Jhansi is under forest. Most of the tropical dry deciduous forests of the region are dominated by Anogeissus pendula.

9.2(b) GEOLOGY AND CLIMATE

The soil of the region, which is residual

in nature, is generally poor in nitrogen, low and medium in phosphate and medium to high in potassium. Mineral rocks are comprised of quarts, feldspar, hornblende, chlorite and mica. The region is subjected to steep slopes, quick run-offs, erratic rainfall, periodic dry spells and unfavourable geology. The climate is transitional between the maritime type of the East and tropical continental dry type of the west. Average annual rainfall is 936 mm and the mean annual temperature is 26.5° C.

9.2.(c) B I O T I C I N F L U E N C E S

Man is directly involved in influencing the local forest vegetation which has been degraded into scrub jungles in some localities. Intensive grazing by cattle (beyond carrying capacity) has led to the development of xeric conditions at some sites. Frequent jungle-fires have resulted in the invasion of some exotic weeds.

9.3 T h e V E G E T A T I O N

9.3.(a) P H Y T O S O C I O L O G Y

During phytosociological studies a total

of 59 tree species made their appearance in five of the forest blocks studied. Site wise the number of tree species occurring in the quadrats were : 25/Bangawa (S-I), 51/Chandpura (S-II), 21/Laxmanpura (S-III), 10/Simravari (S-IV) and 46/Mayakhera (S-V). Five species of the trees viz., Acacia catechu, Acacia nilotica, Bauhinia racemosa, Butea monosperma and Holoptelia integrifolia were the most common associates of Anogeissus pendula in each of the five forest blocks. Percentage distribution of the tree species in Raunkiaer's frequency classes indicate a heterogeneous nature of the tree communities in each of these forests studied.

Bangawa was the most thickly populated forest stand (4052/trees/ha) and was followed by Chandpura (2488 trees/ha), Laxmanpura (2016 trees/ha), Mayakhera (1932 trees/ha) and Simravari (1332 trees/ha). Contributions made by A.pendula in each of these forests were relatively very much higher than of the any other species. It were nearly 49, 47, 51, 67, and 56 percent of the total densities in S-I, S-II, S-III, S-IV, and S-V respectively. A.pendula was also the most

dominant tree species present in each of the five forest sites with its IVI nearly of the following values : 132, 111, 124, 167 and 126 respectively. Butea monosperma was the common co-dominant tree in all the forest blocks. The A/F ratio of A.pendula suggest its contagious distribution in each of the five forest stands.

In all 176 species of 'field layer' appeared in the quadrats during phytosociological study of the ground vegetation. Site wise representation of the herbaceous species were 51/S-I, 89/S-II, 135/S-III, 32/S-IV and 64/S-V. Twenty species were throughout common in all the five forest sites. However, in all 90 species were present exclusively in only oncof the five forests. The site wise likeness of such species were 6, 16, 62, nil and 6 respectively. The percentage distribution of the herbaceous species in Raunkiaer's frequency classes indicate that majority of them were poorly dispersed as they amassed in the frequency class - A.

The ground vegetation of Laxmanpura block was the most luxuriant and densely populated (297

plants/m^2) and was followed by Mayakhera (155 plants/m^2) Chandpura (103 plants/m^2), Bangawa (100 plants/m^2) and Simravari (39 plants/m^2). The most dominant species of the ground layers were different in each of the five sites. In S-I and S-II it was Rungia repens with maximum IVIs nearly 38 and 32 respectively. Cassia pumila, Oplismenus burmanii and Lindernia ciliata were the most dominant species in S-III, S-IV and S-V with IVIs nearly 14, 32 and 27 respectively.

9.3(b) J A I - S U N M O D E L

Most of the ecological systems of statistical formulae give only an idea of the composition and quantitative structure of the community under consideration. Unfortunately, a system of analysis for determining the productive quality of a species or a forest as a whole was lacking till date. Hence, a simple, genuine and reliable eco-mathematical model was devised by the author for determining the various levels of productive quality of trees, both as a species, and collectively as a forest. The model, which cover ups the deficiency in qualitative assessments, has been termed as 'JAI-SUN MODEL' and was formulized ut infra :-

$$\text{Jai - Sun Value} = \frac{\Sigma b_x}{T_i}$$

where, Σb_x : Sum of basal area (m^2) of every individuals of x species assessed.

T_i : Total number of individuals of the x species assessed.

The values arrived through this model were arranged in an index of eight different levels of health or Productive qualities as follows :

A^+	: Excellent,	A	: Superior,
B^+	: Very good,	B	: Good,
C^+	: Fair,	C	: Satisfactory,
D^+	: Poor, and	D	: Very Poor.

Similarly, the average quality or health of a stand as a whole can also be determined ut infra :

$$\text{Jai - Sun Value Of Stand} = \frac{\Sigma (b_x + b_y + b_z)}{T_i \, (x + y + z)}$$

where, x, y and z are various species present in the stand.

The Jai-Sun Values of each individual species

as assessed, suggest that A.pendula trees were generally poor in their average health in Bangawa but were fair in their average quality in rest of the sites with Jai-Sun values of 0.011 (D^+ level), 0.035, 0.026, 0.028 and 0.032 (all C^+ level) respectively. On the basis of their Jai-Sun values, the general strength of the five forest blocks were in the following descending sequence ad val. : Nayakhera (0.031/C^+ level) > Chandpura (0.028/C^+ level) > Simravari (0.027/C^+ level) > Laxmanpura (0.025/C level) > Bangawa (0.015/D^+ level).

9.3.(c) P L A N T A N D L I F E F O R M S

A total of 512 flowering species representing 336 genera and 85 families shared in the preparation of the biological spectrum. Contribution of species in each of the life form classes were :

Therophytes	:	211 sps. (41.2 %)
Chamaephytes	:	128 sps. (25.0 %)
Phanerophytes	:	103 sps. (20.1 %)
Geophytes	:	37 sps. (07.2 %)
Hemicryptophyte	:	33 sps. (06.5 %)

Thus the zonation of vegetation, on the basis of 'Biological Spectrum' can be called as 'Therophytic' indicating hot and dry climate of the region.

Majority of the species in the area studied were erect annuals (46.3 - 61.5 %) with their mode of dissemination through wind or water (37.5 %). Sociologically, a great number of annuals were growing either isolated (53.1 %) or were forming small patches (40.6 %), whereas, most of the perennials were found growing in close associations and thereby forming either open or close colonies.

9.3(d) S T R A T I F I C A T I O N

Stratification of the vegetation indicate that the species dominantly present in each of the 5 layers of the forest vegetation were :

Emergent or A layer	:	Almost none.
Middle or B layer	:	A. pendula
Lower or C layer	:	Zizyphus mauritiana
Shrub or D layer	:	Zizyphus nummularia
Ground or E layer	:	Aungia repens

9.3.(e) S Y S T E M A T I C S

Fabaceae (including Papilionaceae, Caesalpiniaceae and Mimosaceae) was the most dominating family present in the area. It consisted of 86 species covering 41 genera. Poaceae was the second largest

family with 75 species under 55 genera followed by Asteraceae (40 spe.), Cyperaceae (21 spe.) and Euphorbiaceae (19 spe.). Cyperus was the biggest genera of the area inspected, with a maximum of 10 species. It was followed by Cassia, Eragrostis and Indigofera each with 8 species. The monotypic families representing the area were 29 in numbers, whereas, the monogeneric families were 10. The proportion of species, genera and the families belonging to the monocots and the dicots were at infra :

Monocots : Dicots

Species = 1 : 3.83

Genera = 1 : 4.01

Families = 1 : 16

Genera : Species

The whole of India = 1 : 7

The Upper Gangetic Plains = 1 : 2.2

The present study = 1 : 1.52

This show the small proportion of species to the number of genera in the area. It also confirms to the general rule that within the same floral region, the smaller the flora, the smaller the genus : Species ration.

9.3.(f) H A B I T A T M O D I F I C A T I O N S

Breaks in the pattern of variation were noticed

by recognising two different kinds of A.pendula with differences in the appearance of 'Kardhai' especially in the size and the erectness of the species. It is presumed that these phenotypic plasticity were actually some sort of adaptations in response to particular need or the utility and were certainly associated with some ecological factors. A tremendous pressure of grazing and browsing forced A.pendula to appear as Kar.-1 i.e., very much reduced in its height, spreading all along the ground and appearing like a green carpet during and after rains. Whereas, the excessive, indiscriminate and illegal cutting of the forest trees particularly 'Kardhai' by the local villagers, compelled A.pendula to adapt itself as Kar.-2 i.e., bushy or spiny and armed in its appearance. Both these forms assumed a thorny semblace probably a device for protection against the struggle for existence.

9.4 SEED CHARACTERISTICS

IN seed testing, physical and the biological characteristics of a seed-lot are measured to assess the value of the lot. These tests help in fixing the quality and other characteristics of the commodity and are also of great merit to the seedsman and or the nursery man.

9.4.(a) P U R I T Y T E S T

The purity test is usually the first test to be performed as it provides pure seeds for other tests. The seed samples of six different localities contained varying amount of seed and non-seed components. The highest proportion of the seed component was recorded in Chandpura seed-lots (88 %)followed by Nayakhera (76 %) and Bangawa (69 %) samples, whereas, the highest proportion of the non-seed component was observed in Sikravari seed samples (50 %) followed by Jharar (40 %) and Laxmanpura (35 %) seed lots. The seed component was comprised of the following constituents :

A. - Pieces of broken seeds.

B. - Insect damaged seeds.

C. - Abnormally shaped seeds.

D. - Shriveled and cracked seeds. And

E. - Normal and pure seeds.

Whereas, the non-seed component was made up of the following constituents :

A. - Inflorescence axis.

B. - Branches, twigs, barks etc.

C. - Dry and fresh leaves.

D. - Insect galls. And

E. - Seed or seed-like structures of other species.

Collective average composition of pure seeds in a seed lot of A.pendula was about 56 % by weight. Chandpura block contained relatively higher percentage of pure seeds (77 %) followed by Nayakhera (62 %), Bangawa (57 %), Laxmanpura (54 %), Jharar (48 %) and Simravari (37 %) in secundum ordinem.

9.4.(b) S E E D W E I G H T A N D S I Z E

Aggregate average weight of A.pendula seed was slightly above 6 mg. However, the weight ranged from minimum 1 mg to maximum 17 mg or more depending upon the size and the volume. This variation might have also been affected due to the differences in moisture contents and the proportion of seed fillings in form of stored reserve food materials and the embryo itself. Number of seeds per gram lot of 'Kardhai' ranged in between 100 to 275 depending upon their individual weights. The variation in number due to differences in size and the weight of the seeds could be assigned to the result of inherent genetic differences, climatic and other conditions under which the seeds matured.

Cumulative average volume of A.pendula seed was 0.17 cc and it oscillated from 0.01 cc to 0.50

ce in different sites. Volume of seed was directly proportional to its size and the thickness. Average length, breadth and the thickness of seed in heaped lots were : 6.2 mm (2.8 mm - 8.6 mm), 4.9 mm (2.3 mm - 7.2 mm), and 1.7 mm (0.7 mm - 2.5 mm) respectively. Values provided within parenthesis are minimum and the maximum ranges of the said parameter. Size-index fluctuated from 7 mm^2 to 61 mm^2, whereas, the shape-index varied from 1 to 1.8 i.e., seeds of 'Kardhai' were generally small in size and were nearly square to somewhat rectangular in their shape.

9.4.(c) M O I S T U R E C O N T E N T S

The fresh seeds of A.pendula contained 13.4 % of moisture contents by weight which swunged in between 9 % to 19 % depending upon the level of seed maturity. Kardhai seeds generally imbibed nearly equal amount of water by their weight to become fully turgid in order to initiate the process of germination. This requirement was fulfilled after 48 hours of continuous soaking of seeds at room temperature.

9.4.(d) V I A B I L I T Y

Rapid estimation of viability suggest that living seeds varied in composition with regard to sites.

In biochemical staining the seeds exhibited 15 % viability. However, the number of live seeds rocked from 4% to 21 % depending upon the out-turn of the fertile seeds. Production of unfertile seeds seems to be the major factor, which could be held responsible for poor percentage of germination in A.pendula. Unfertile seeds might be produced due to the excessive seed abortions and probably were also the result of failure in fertilizations. *au reste*, both, climatic and the biotic factors play equally important roles in seriously affecting the developmental processes of A.pendula seeds.

9.5 S E E D G E R M I N A T I O N

Seed germination is a well programmed process controlled by both, the internal and the external factors. The experiments designed to study the germination behaviour of A.pendula seeds as influenced under various pre-treatments of the seeds were *ut infra* :

(i). Effect of substratum (Petridish & Nursey bed),

(ii). Imbibition period,

(iii). Dry and wet heat pre-treatment,

(iv). Hot water treatment,

(v). Light conditions,

(vi). Sulphuric acid pre-treatment,

(vii). Growth hormones,

(viii). Allelopathy,

(ix). Seed weight and seed size, and

(x). Potting media.

9.5.(a) E F F E C T O F S U B S T R A T U M

The germination of A.pendula seeds was relatively more in petridishes lined with two layers of blotters as compared to that of on top of the raised nursery beds. The germination percentage and the emergence time varied an rapport their sites of collection, with minimum 1 % to maximum 11 % and minimum 2 days to maximum 8 days respectively. Variation in the moisture contents, water holding capacity and the relative turgidity of the seeds were mainly responsible for the differences in the germination percentage and the emergence time.

9.5.(b) I M B I B I T I O N

A comparatively better response of germination in soaked seeds in a very short duration of time and the poor or negligible response in sulphuric acid treatments firmly indicates that in A.pendula seeds

the dormancy, if present, was not imposed at all by its seed coat. However, the seeds were sensitive to both, the moisture and the temperature. The soaking of seeds gradually increased the germination percentage with subsequent increase in both, the temperature and the duration of soaking. Whereas, soaking of the seeds at low temperature (5° C) gradually decreased the germination with progressive increase in the duration of soaking. It is presumed that imbibition of seeds triggered some particular metabolic sequence that was further amplified by the temperature. A maximum of 26.18 % increase in the germination was perceived in the seeds soaked at 35° C temp. for a minimum period of 24 hours in relation to the germination obtained under control.

Similarly, the results of dry (unsoaked) and wet (soaked) heat (40° C) pre-treatment recorded a maximum of 41.46 % germination profit over control in the soaked seeds incubated for 2 days, whereas, 36.59 % germination gain was noticed in relation to control in the unsoaked seeds incubated for 5 days. This specifies that the seed-bed temperature should be given proper consideration for obtaining a good amount of Kardhai seedlings.

In hot water treatment a maximum of 24.39 % enhancement in the germination was documented in the seeds treated at 50° C temp. for a period of 60 minutes as regards the germination attained in the seeds under control. Treatments below and or beyond this temperature proposed a decrease in the germination percentage regardless of the duration of the treatment.

The experiment conducted to observe the effects of light conditions on the germination behaviour of A.pendula seeds revealed that an exposure of seeds to the continuous light or to the complete darkness relatively mitigated the germination percentage. An increase in germination was recorded in diffused light conditions. This supported the field observation in that there was considerably increased number of seedlings of 'Kardhai' in the shaded area under vegetal cover.

A remarkable and the best response of germination (92.5 % bounce over control) was registered in the seeds soaked in 1000 ppm/IBA followed by 500 ppm/IBA with a 40 % increase in relation to the control. An increase or the decrease in the germination percentage in response to other growth hormones viz., Indole acetic

acid, Indole propionic acid, Kinetin, Maleic Hydrazide and Coumarin were not of much significance except an increase of 35.71 % germination in the seeds soaked in 50 ppm/G.A.

Leachates of Acacia catechu, Acacia nilotica and Eragrostis ciliaris were negative allelochemics, whereas, the leachates of A.pendula (self compatibility), Butea monosperma, Holoptelia integrifolia and Mungia repens were positive allelochemics. However, the results attained were not of much delight that can be engraved.

The results of seed polymorphism indicate that the medium sized seeds of A.pendula were highly viable as compared to the low viability in large and small sized seeds. Regarding weight, viability was highest in the heavy weighted seeds in a decreasing sequence.

Effects of four different potting media viz., sand, red soil, black soil and peat, on the custom of A.pendula seed germination guides that the pure sand as a medium was best suited for germination followed by the red soil. Black soil and the peat when used as a medium displayed poor germination.

9.6 GROWTH PERFORMANCES

FORESTS are complex environments in which the seedling growth of its constituent species may be limited by a large number of factors both environmental and physiological. In order to understand the affects of some factors on the growth behaviour of A.pgndula seedlings, the following experiments were conducted for twelve months period :

(1). Inorganic fertilizers,

(2). Growth hormones,

(3). Seed polymorphism,

(4). Soil compositions, and

(5). Planting density,

The average length of roots formed, ranged from a minimum of 7.82 cm in the seedlings obtained through light weighted - large sized seeds to a maximum of 64.88 cm in the seedlings grown with a dose of Phosphorus - 20 kg/ha. Similarly, the biomass of the roots also fluctuated with their lengths from a minimum of 0.5492 g to a maximum of 3.6754 g in the same ut supra respective treatments.

The maximum and the minimum averages of (a)- number, and (b)- the total length of secondary roots

produced in the seedlings oscillated to and fro in between (a)- 50.2 in a soil composition of pure sand and 10.4 in light weighted - large sized seeds and (b)- 94.8 cm in both, the Phosphorus + Potassium - each 20 kg/ha dose and merely in sand, and 12.6 cm in light weighted - large sized seeds respectively.

The maximum and the minimum average photosynthetic area of leaves produced by a seedling, rocked from 170.2 cm^2 in 500 ppm/KN sprayings to 29.8 cm^2 in soil composition of pure peat. The average dry weight of the leaves varied from 1.2146 g in 500 ppm/KN to 0.3058 g in light weighted - small sized seeds.

The maximum and the minimum average lengths of the shoots produced by a seedling roamed from 40.78 cm in 500 ppm/IBA sprayings to 8.28 cm in light weighted - large sized seeds, whereas, the biomass of shoots rocked from 1.8332 g in 500 ppm/KN treatments to 0.5168 g in the soil mixture containing pure peat.

The average total length of the A.pendula seedlings swayed from a maximum of 100.36 cm in 500 ppm/IBA to a minimum of 16.10 cm in light weighted - large sized seeds. The average dry matter productions

swunged from a maximum of 5.0564 g to a minimum of 1.0720 g in the same *ut supra* treatments.

The average shoot - root length ratios of *A.pendula* seedlings quivered from a maximum of 1.0588 in light weighted large sized seeds to a minimum of 0.3213 in a soil composition of sole sand. The S/R ratio of dry weights vibrated from a maximum of 1.0699 in a soil mixture of peat and black soil in 3 : 1 ratio by volume to a minimum of 0.2474 in Phosphorus - 40 g/ha treatments.

9.7 R O O T - S U C K E R S

THE outcome of the studies in identifying, locating, and understanding the structural morphology of *A.pendula* root suckers were that in nature the suckers were very common in this tree. The sucker generated plants were in form of culms and were abundant especially in the open forests. These culms were able to grow upto the normal height of parent tree depending upon the external climatic and biotic conditions.

On an average, the sucker generated plants per parent tree were comparatively more in the trees present on slopes than that of the trees on top and

base. On slopes, A.pendula trees were found to possess the capacity of sprouting suckers very early in their life even when they were quite young, whereas, on base it were generally the more matured trees which exhibited sprouting of suckers. Usually the sucker producing parent trees were comparatively of lesser height on slopes.

Optimum circumferences of the parent roots, capable of sprouting suckers, seems to be in the range of 8 cm to 15 cm. Normally, the suckers sprouted from the horizontal root system of the parent trees on or slightly below the soil furface. Roots of 'Kardhai' trees were found to form asecciations. These associations, known as 'Root-grafts', were observed in between the root branches of the same parent tree, as well as in between two or more individuals of the same species.

9.8 SILVICULTURAL TREATMENTS

VEGETATIVE propagation techniques are a vital tool in tree improvement progrenmes. Different silvicultural techniques were attempted on A.pendula and the results discussed. Of particular promise was the propagation through root - sucker plantations. The skills tried were :

(1). Branch cuttings,

(2). Root cuttings, and

(3). Root - sucker plantations.

Sprouting of leaves occured generally in all the categories of branch cuttings of A. pendula, irrespective of their age and hormonal treatments including control. However, these sprouted leaves abscissed abruptly within two months of the plantation. None of the branch cuttings were able either to initiate rootings or to form callus upto 6 months after their plantations. Exogenous application of hormones were also found to be a failure in inducing rootings.

Planting of root cuttings neither sprouted the shoots nor initiated the rootings upto six months even under three different positions of their planting viz. vertical, curved and horizontal.

Planting of 10 - 15 cm long root suckers of A. pendula were found to be a fruitful method for vegetatively propagating the species. This silvicultural method of artificial regeneration seems to be the most economical and of much practical utility. The planted suckers established themselves with ease due to their very

good rooting responses even without applying any root inducing hormones on them.

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C H A P T E R - XI

A P P E N D I C E S

APPENDIX - I

F O R E I G N P H R A S E S
FROM CLASSICAL AND MODERN LANGUAGES AND USED IN THE TEXT

ab ovo (L.)	- From the begining
ad finem (L.)	- In the end
ad incunabulis (L.)	- From the cradle
ad rem (L.)	- To the point
ad val. (L. - ad valorem)	- According to value
a fond (Fr.)	- Thoroughly
alter idem (L.)	- Another similar
a mon avis (Fr.)	- In my opinion
a peupres (Fr.)	- Nearly
aqua bulliens (L.)	- Boiling water
au contraire (Fr.)	- On the contrary
au reste (Fr.)	- Besides
bis in dies (L.)	- Twice a day
cela va sans dire (Fr.)	- It is an established fact
compte rendu (Fr.)	- A report
de facto (L.)	- In fact
de novo (L.)	- A new
e.g. (L.- exempli gratia)	- For example
en rapport (Fr.)	- In relation with

et.al. (L.- et alia)	- And others
etc. (L.- et cetera)	- And the rest
et.seq. (L.- et sequentes)	- And those that follow
hac lege (L.)	- Under this condition
hoc anno (L.)	- In this year
ibid. (L.- ibidem)	- In the same place
i.e. (L.- id est)	- That is
ignotum per ignotius (L.)	- To explain the unknown by the still more unknown
in esse (L.)	- In fact
in situ (L.)	- In its original situation
in terrorem (L.)	- As a warning
in toto (L.)	- Entirely
magnum opus (L.)	- A great work
mirabile dictu (L.)	- Wonderful to tell
per diem (L.)	- Daily
post hoc (L.)	- after this; therefore because of this
pro rata (L.)	- In proportion
proxime accessit (L.)	- He came next
savoir faire (Fr.)	- Skill; The knowing how to do
secundum ordinem (L.)	- According to order
seriatim (L.)	- One after another

ut infra (L.)	- as below
ut supra (L.)	- as above
vice versa (L.)	- The other way round
viz. (L.- videlicet)	- Namely

The abbreviations denoting the language of origin of the phrases are ut infra :

Fr. - French

L. - Latin

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1983. Litter production and its disappearance in a grassland community. Geobios, 10 : 124 - 126.

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